SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1900.

GENERAL PHYSICS.

1621. *Automatic Sprengel Pump.* **W. Donle.** (Zeitschr. Instrumentenk. 20. pp. 78–82, March, 1900.)—This paper describes a form of Sprengel vacuum pump with one fall-tube in which the mercury is raised again to the high level by means of an ordinary aspirator. In order to raise the mercury through the necessary height, which is greater than the barometric height, it is sucked up by the aspirator at a greater rate than it is supplied by the fall-tube, thus making the mercury column in the suction-tube a broken one, with bubbles of air between the mercury threads similar to the column in the fall-tube. J. B. H.

1622. *Pendulum with Constant Electric Control.* **C. Féry.** (Comptes Rendus, 130. pp. 1248–1250, May 7, 1900.)—The pendulum is kept in regular motion by means of a special transformer that gives induced currents, which carry a quantity of electricity independent of the battery, and which can be regulated at will. G. E. A.

1623. *Hardness of Elements.* **J. R. Rydberg.** (Zeitschr. Phys. Chem. 33. pp. 353–359, May 2, 1900.)—The author has collected and compared all available information as to the hardness of the elements, and expresses the results, according to Mohs' scale, in the form of a table and curves. The hardness, like many other physical properties of the elements, is shown to be a periodic function of the atomic weight. N. L.

1624. *Relative Effusion of Argon, Helium, and other Gases.* **F. G. Donnan.** (Phil. Mag. 49. pp. 423–446, May, 1900. Paper read before the Physical Society of London.)—This paper gives the results of an experimental investigation of the relative effusions of argon, helium, and other gases. The gases passed from one vessel into another, previously evacuated, through a very small hole, and the time taken for the pressure in the receiving vessel to rise from zero to a certain amount was measured. The paper begins with a discussion of the mathematical treatment of the subject, and then describes the apparatus used in the investigation; but for this as well as for an account of the difficulties met with in the investigation, reference must be made to the paper.

The results are as follows :—

1. Argon is found to effuse, when compared with oxygen, 8½ per cent. faster than as calculated by the law of the inverse square root of the density. This result is independent of any masking effect due to viscosity.

2. This result is, further, in qualitative agreement with the adiabatic theory of the efflux of ideal gases, and is, if this may be granted, a confirmation of the high specific-heat ratio of argon.

3. When viscosity-effects are eliminated or allowed for, it is found that hydrogen, oxygen, and carbon monoxide effuse relatively in the manner predicted by the theory for ideal gases possessing the same, or nearly the same, specific-heat ratio.

4. Carbon dioxide, when compared with oxygen, appears to effuse about 1 per cent. *faster* than as calculated from the densities. This result is not in accordance with the adiabatic theory of the efflux of *ideal* gases.

5. The results obtained for helium are not uniform, and are affected by a viscosity-correction depending on an empirical formula. They are sufficient, however, to show that the behaviour of helium is unlike that of argon—a result which is not foreseen by the theory.

6. If account be taken of the deviation of ordinary gases from the ideal laws, it is possible to obtain an expression for the efflux which contains a correction-term involving the constant K of the Thomson-Joule effect.

7. The sign of this correction-term shows that a real gas will effuse more *rapidly* or more *slowly* than an ideal gas of equal density and specific-heat ratio, according as K is *positive* or *negative*.

8. The suggestion is made that possibly the anomalous results obtained with carbon dioxide and helium may be thus explained. The deviations of the observed results from the results calculated for an ideal gas are, in the case of CO_2, in *qualitative* accordance with the theory proposed. In the case of helium they would be so if that gas possessed a negative K. J. B. H.

1625. *Temperature of the Acetylene Flame.* **E. L. Nichols.** (Phys. Rev. 10. pp. 234–252, April, 1900. Paper read before the American Physical Society, Feb. 24, 1900.)—The author gives the results of experiments made to determine the temperatures at different points of an acetylene flame, for which various observers have given widely different numbers; thus Le Chatelier gave 2,100–2,420°, whilst Lewes found a maximum temperature of 1517°, Smithell's values being intermediate between these two. The flame employed by the author is of the usual flat type, the burner being capable of lateral motion by means of a micrometer screw. The thermo-electric couples are composed of platinum and platinum-rhodium (10 per cent.) wires, of thickness varying from 0·01996 to 0·00821 cm.; the ends of the wires are pinched together in the form of a **V**, the point of which is fused by plunging into an oxy-hydrogen flame, and then cut off so as to leave a connection about 0·005 cm. thick. The E.M.F. produced at the heated junction is measured by a potentiometer and Clark cell. To observe the acetylene flame, and to measure the distance between its median plane and the thermo-element, a magnified image is obtained on the ground glass of a micro-camera, the plane of the flame being arranged parallel to the axis of the camera. The thermo-junction is placed at a distance of 6 mm. from the median plane, and the temperature taken by balancing the potentiometer, the junction then being gradually brought up to the middle of the flame, the temperature at each new position being determined. With each of the four couples used, the temperature is found to increase gradually at first, but at a distance of about 0·4 cm. from the middle the curve suddenly becomes steep, so that this distance probably measures the thickness of the layer of non-luminous gas surrounding the well-defined luminous layer, which has a thickness of about 0·065 cm. Before this luminous layer is reached, the temperature curve shows signs of approaching a maximum, the thicker junctions (0·01996 and 0·01598 cm. diameter) being coated with carbon and considerably cooled when coming into contact with the luminous region. The thinner couples give temperature curves lying above those of the thicker ones, and give no deposit of carbon, but are melted in the middle portion of the flame, one of them after passing the median plane and the other before that plane is reached. By extrapolation the temperatures at various parts of the flame for a thermo-junction of negligible cross-section can be estimated; by this means the temperature at the middle of the flame is found to be 1,900°, whilst at 1 mm. from the middle the value is 1,920°. Similar experiments with a luminous coal-gas flame indicate its highest temperature to be 1,780°, the value for a candle flame being 1,670°. The fact that a thin platinum wire—prepared by Wollaston's method of silver-plating it, then repeatedly drawing through a die to diminish its diameter and finally dissolving away the silver—can be melted in a candle flame, the author shows is due to the presence of impurities in the wire which make it melt at 1,674°, whilst pure platinum melts at 1,775°. The temperatures given by the author are based on an arbitrary scale in which the melting-point of platinum is taken as 1,775°, and that of gold as 1,070°. T. H. P.

1626. *Vertical Electric Seismoscope.* **G. Agamennone.** (Accad. Lincei, Atti, 9. pp. 204–210, March 18, 1900.)—A strong upright brass column carries at the top a cross-piece supporting three spiral springs, which hang vertically down. The two outer ones support a lead weight of about 1 kilogramme, to the centre of which is attached a platinum point. The middle spring is weighted with a less weight, and while the former oscillates about twice per second, the latter oscillates two or three times more rapidly. The smaller weight carries another spring supporting a third weight in the shape of a flat brass cylinder, which oscillates still more rapidly. Its lower surface is gilt, and just touches the platinum point attached to the largest weight. The instrument is prepared for use by adjusting the springs so that the platinum point is at a certain slight distance below the reflecting surface, the adjustment being aided by the image of the point in the surface. The point and the surface are connected to the two terminals of a chronograph circuit.

The author also describes an instrument which is a combination of the above and his older instrument for the registration of horizontal wave motions. He claims that both are cheap and efficient. E. E. F.

1627. *Capillarity.* **G. Bakker.** (Zeitschr. Phys. Chem. 33. pp. 477–499, May 18, 1900.)—The author maintains that the proofs of Jurin's law usually given are incorrect, in that they treat of thermal pressure and cohesion as additive quantities, whereas he maintains that they are different in character; as he expresses it, the field of action of the one is a surface, of the other a space. And this difference in character, and not merely the change of form in the surface of the liquid, he holds to be the cause of the observed phenomena.

Referring to Neumann's investigations, in which the principle of virtual displacements is applied, he holds that in the equations $\frac{du}{dx} + \rho\frac{dv}{dx} = 0$, &c., where v denotes potential, and ρ the density, u is not the hydrostatic, but the thermal pressure. He then shows by considerations regarding the surface tension that within the capillary layer the hydrostatic pressure is a vector and not a scalar.

He then investigates the potential function of capillarity. To this end we have choice of two methods, namely, to construct a homogeneous medium which shall present the same force-phenomena as the liquid, or, secondly, to regard the liquid as an assemblage of moving particles under dynamical laws. He chooses the former method, and assumes that at every point in the medium not within the capillary layer, the resultant force, not merely is on the average, but is always, zero, so that if ψ be the potential, $\frac{d\psi}{dx}=\frac{d\psi}{dy}=\frac{d\psi}{dz}=0$, from which data he obtains $\psi=-f\epsilon^{-qr}/r$, where f and q are constants. Also q is the reciprocal of a line, say, $fq=\frac{1}{\lambda}$. It is then shown that any solution of the equation

$$\nabla^2\psi=q^2\psi+4\pi f\rho$$

is unique.

The energy per unit of volume assumes the form

$$W=-\frac{1}{4\pi f}(R^2+\frac{\psi^2}{\lambda^2})$$

where R is the force derived from ψ. This is reduced to the Newtonian form by making λ infinite, or $\psi=-\frac{f}{r}$. The capillary surface tension is then discussed and the molecular pressure, and a value is obtained for Laplace's function H. In conclusion he finds that the capillary surface tension is connected with a difference between the forces acting parallel and perpendicular to the surface of the capillary layer. S. H. B.

1628. *Telescopic Planets.* **C. de Freycinet.** (Comptes Rendus, 130. pp. 1145–1154, April 30, 1900.)—The author analytically examines the conditions following the breaking up of the primary sun in the centre of our system, which gave rise to the swarm of asteroids, or minor planets, now revolving between Mars and Jupiter. He discredits the idea that the whole of these bodies originated from a single ring thrown off from the central body, and by examining the elements of their orbits has been enabled to classify them into groups, the members of each group being related closely by their elements. He therefore concludes that these small planets have been formed by the successive detachment of spherical layers from the central sun, each having its own rate of rotation, &c. He then divides the 428 planets at present known into three groups, according to the mean inclination of their orbits, and finds that the mean distance from the sun and the eccentricity both vary so regularly as to be noticeable. Thus—

Inclination of Orbit.	Eccentricity.	Mean Distance.	No. of Planets.
0° – 10°	0·1332	2·757	237
10° – 20°	0·1574	2·771	162
20° – 30°	0·2042	2·813	28

C. P. B.

LIGHT.

1629. *Standards of Light.* **J. E. Petavel.** (Roy. Soc., Proc. 65. pp. 469–503, Jan., 1900.)—Various classes of standards of light are described by the author which belong to the two main divisions: (1) Flame standards, and (2) Incandescent standards. He considers at some length the arc light standard, and concludes that the intrinsic brilliancy of the crater of a silent arc is about 147 c.p. per sq. mm.; and that even when the most favourable conditions are selected, and the intensity of current and the length of the arc are maintained constant, it is difficult to obtain consistent results, variations of over 5 per cent. being by no means unfrequent. The crater of the arc does not, therefore, possess the qualities required of a standard. Incidentally the experiments made confirm the theory that the crater of the arc is at the temperature of volatilisation of carbon.

The author next describes and considers the Lummer and Kurlbaum incandescent platinum standard, and then gives an account of researches on the molten platinum standard of light. The methods of fusing platinum by the electric current, and by the oxy-hydrogen blowpipe, are described. To ensure suitable conditions and a pure surface (1) the platinum must be chemically pure, (2) the crucible must be made of pure lime, (3) the hydrogen burned must contain no hydrocarbons, and (4) the gases should be burnt in the ratio of four volumes of hydrogen to three of oxygen. A large number of observations extending over a long period of time were made. It was found that the effect of contaminating the platinum with either silica or carbon was very marked. From the results of his work the author states that the probable variation in the light emitted by molten platinum under standard conditions is not above 1 per cent., and the accuracy of this standard is capable of being increased. Physiological considerations fix a limit to the accuracy of photometric observations. It is not impossible that the accuracy of the platinum standard may attain to or even surpass this limit. J. J. S.

1630. *Alteration of Surface Properties of Metals by Light.* **H. Buisson.** (Comptes Rendus, 130. pp. 1298–1300, May 14, 1900.)—Sunlight causes a diminution in rapidity of discharge from an amalgamated zinc plate, and this effect is not permanent. The potential of a plate also varies under the action of sunlight. A large number of metals become more negative after illumination, but platinum becomes more positive. A plate is found, in general, to have two definite potentials in darkness and in light, and there is an inversion wave-length, such that more refrangible waves cause a negative variation of potential, less refrangible a positive variation. For zinc this wave-length is $0{\cdot}310\ \mu$. G. E. A

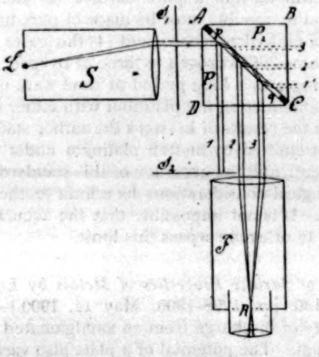
1631. *Optical Illusions.* **A. Wyczólkowska.** (Acad. Sci. Cracovie, Bull. 1. pp. 7–23, Jan., 1900.)—The paper treats of the optical inversion observed in perspective drawings as of hollow cones, &c., and experiments show: (1) That the maximum speed of inversion is about that of the observer's pulse, but is no function of it. (2) The inversion of plane figures is accompanied by a change in refraction of the eye, as proved by means of an ophthalmometer. (3) That there is an inversion between the real and the illusory image as shown by solids, and there is also an inversion from one illusory image to another as shown by plane figures. (4) The inversion in solids is accompanied by four distinct phenomena, viz.: (i) Changing of the intensity of the light, tone, colour, and form of the object observed; (ii) the duration of the image; (iii) the movement of the image; and (iv) the inclination of the image; this latter being a function of the angle at which the eye observes the object. An explanation of the cause of inversion is given.

G. E. A.

1632. *Complementary Interference Fringes.* **O. Lummer.** (Preuss. Akad. Wiss. Berlin, S.ber. 24. pp. 504–513, May 3, 1900.)—If one looks at a bright surface through two right-angled prisms placed with their hypothenuses together, but separated by a thin film of air, and if the eye is focused for parallel rays, one sees a system of interference fringes parallel to the line bounding the area of total reflection. The present paper contains a study of these fringes, and the author has discovered that in reflected light two systems of fringes are obtained, one system being the complementary of the other.

The method of experimenting is seen in the diagram. The double prism BD is mounted on the table of a goniometer, of which S is the collimator

Fig. 1.



and F the telescope, both focussed for parallel rays. The slit is illuminated by an Aron's mercury lamp. S_1 is a slit diaphragm, and S_2 a screen with which any number of the reflected beams 1, 2, 3, &c., may be cut off. If S_2 is absent, then the field to the right of R appears brightly illuminated by the totally-reflected light of the lamp, and to the left of R the interference minima appear on a blue white ground, the fringes being coloured from the different wave-lengths present in the mercury light. If S_2 is now placed so as to cut off the beams 1 and 2 the field changes to the complementary; the field to the right of R appears dark, while to the left of R on a dark ground bright interference maxima appear.

The theory of the phenomena is fully explained in the paper. J. B. H.

1633. *Spherical Aberration in Double Achromatic Objectives.* **W. Harkness.** (Amer. Journ. Sci. 9. pp. 287–291, April, 1900. Paper read before the Philosophical Society of Washington in a slightly different form, Oct. 28, 1898.)—The main part of this paper is devoted to proving that in any thin lens, if the spherical aberration is completely corrected for all objects situated in the axis of the lens, then the oblique aberration will also be completely corrected.

The problem of obtaining equally good definition all over the field of view is thus reduced to the problem of making the destruction of spherical aberration for axial rays independent of the distance of the radiant from the telescope. This problem was solved by Herschel in 1821, so that objectives made according to his rules will give good definition throughout a wider angle than any other double achromatic objective. J. B. H.

1634. *Anisotropic Prisms.* **C. Viola.** (Accad. Lincei, Atti, 9. pp. 196–204, March 18, 1900.)—The author deals with prisms made of uniaxial or biaxial crystals obeying Fresnel's laws. He decomposes the total deviation of the incident beam into two components, termed the longitudinal and the lateral deviations respectively, and proves the following theorems: (1) The minimum deviations for a given value of the azimuth occur in the case of a plane wave parallel to the first bisectrix of the prism. (2) The lateral deviation is zero when the plane wave is parallel to the first bisectrix or to the edge of the prism. (3) When the plane wave is parallel to the edge of the prism the minimum deviation is the absolute analytical minimum of all the deviations possible in an isotropic prism. (4) The wave plane parallel to the first bisectrix of the prism gives a minimum deviation when it is normal to a plane of symmetry of the crystal. (5) In such a case the lateral deviation is zero, as in the case when the wave plane is parallel to the edge of the prism. Theorems (4) and (5) offer a new and simplified method for determining the indices of refraction of a bi-refracting prism. For when the lateral deviation is zero the minimum deviation and the azimuth are sufficient to determine the principal index of refraction. E. E. F.

1635. *Formulæ for Lenses.* **L. Pfaundler.** (Akad. Wiss. Wien, S.ber. 108. pp. 477–489, 1899.)—This paper contains a criticism of the nomenclature with regard to lenses which was first introduced by Gauss, and is now in general use. The criticism applies particularly to the terms "convergent" and "divergent." For very thick lenses this nomenclature is misleading, and the author in this paper investigates all the possible cases. He shows that a lens is convergent or divergent not according as the second focal length is positive or negative (Gauss), but according as the distance between the second focus and the second surface (Schnittweite) is positive or negative, and he advocates the division of lenses into positive and negative accordingly. A lens is best represented by its radii of curvature, and these he calls + or — according as the centre of curvature is in the direction of motion of the light or the reverse. A lens may be completely represented, then, by two pluses or two minuses or one plus and one minus, the two signs being separated by a sign of equality, greater than, or less than, according as the first radius is equal to, greater or less than the second. J. B. H.

1636. *Crystalpolymeter for the Examination of Crystals.* **C. Klein.** (Preuss. Akad. Wiss. Berlin, S.ber. 18. pp. 248–257, March 29, 1900.)—The author gives a description of the construction and method of working of a new three-circle goniometer, which can be used for the following determinations: (1) Crystal angles. (2) Refractive indices by means of prisms, of solids, and (3) of liquids. (4) Refractive indices of solids by total reflection in liquids.

(5) Examination of crystals in equally refrangible media for (*a*) determining the position of the axis and axial angle and measuring the latter, and (*b*) fixing the positions of extinction for the faces of a zone. (6) Investigation of thin and thick plates in parallel and in convergent polarised light. T. H. P.

1637. *Telemicroscope.* **A. Deschamps.** (Comptes Rendus, 130. pp. 1176–1177, April 30, 1900.)—This is an instrument which enlarges by about 12 diameters objects placed at a distance of some 25 cm. It thus enables the observer to study insects without disturbing them from their normal surroundings. The instrument consists of two Dollond achromatic lenses separated by a distance less than the focal length of the most converging lens. These form the objective. The eyepiece is a lens of short focus, chosen so as to give the maximum enlargement and field. The depth of focus of the instrument is very great, and it gives effects of relief similar to stereoscopic effects. No detailed description is given. E. E. F.

1638. *Artificial Colour-blindness and Successive Contrast.* **G. J. Burch.** (Roy. Soc., Proc. 66. pp. 204–216, April, 1900.)—The author's observations on artificial colour-blindness seem unfavourable to the theory of Hering and favourable to that of Young. An account is first given of opinions held on this subject before the time of Young. There were two groups of opinions in the eighteenth century. One school held that after the stimulus of a strong light of any given colour a species of reaction sets in, and the sense of the supplementary colour is produced. The other school, from which the theory of Young developed, seems to have been founded by Scherffer, who suggested that a continuous action of, for instance, red light, may so change the order and arrangement of the parts of the back of the eye that those rays which are peculiarly fitted to act upon that particular part may be no longer strong enough to communicate to those parts the necessary vibratory movement until a little rest shall have restored them to their condition, and during this time the other rays of different kinds will not cease to act. A description is next given by the author of the present paper of his experimental investigation of the phenomena of successive contrast. This is an effect of two stimuli—a primary stimulus by which the retina is fatigued, and a secondary stimulus, the effect of which is modified in consequence of the first. The colour-sensations excited may be reduced to four at the most. To arrive at the fundamental laws of contrast the conditions may be varied as follows: Let the first stimulus excite a colour-sensation, taking each in turn or separated from the rest as in the spectrum. Four cases arise:—

(1) The second stimulus may excite all the sensations, *i.e.*, it may consist of white light. This gives the complementary colour, *i.e.*, the direct spectrum, as R. W. Darwin calls it, of all the colours save that excited by the first stimulus.

(2) The second stimulus may excite the same sensation as the first, but less strongly. This gives a black after-image.

(3) The second stimulus may excite two or more colour-sensations including that of the first stimulus. The colour of the resulting image is that of the second stimulus *minus* the first.

(4) The second stimulus may excite one or more sensations, none of which were included in the first stimulus. The colour of the resulting image is that of the second stimulus *plus* the admixture, usually small, of the first.

Experiments illustrating the above cases are described, which include the following:—

1. After fatiguing the retina by the spectrum, a uniform white light is observed. This is done most readily by means of a low-power spectroscope with a reflected-scale tube.

2. After fatiguing the retina by the spectrum, a less intense spectrum is observed. The effect upon the retina of light of any wave-length is to blind the eye temporarily for light of that same wave-length.

3. After fatiguing the retina by any one colour, the entire spectrum is observed. A very transient colour-blindness is here produced.

After giving the details of the above experiments, contrast phenomena by intermittent stimulation are mentioned, and an account is given of the experiments of S. Exner and Shelford Bidwell, which have been repeated and continued by the author of this paper. J. J. S.

1639. *Artificial Colour-blindness.* **G. J. Burch.** (Roy. Soc., Proc. 66. pp. 216–219, April, 1900.)—The author wishes to guard against the supposition that the results described by him (Phil. Trans. B. vol. 191, 1899) are phenomena of a pathological condition induced by severe strain in the structure of the eye. The same phenomena occur with the faintest light the eye is capable of perceiving. The following experiments illustrate this statement:—

1. The observer's left eye was exposed to direct moonlight in the focus of a lens behind a screen of ruby glass combined with a gelatine film stained with magenta. After three minutes the observer looked through a spectroscope directed to the moon. The red had entirely disappeared, and only the green, blue, and violet were visible. With the right eye the red as well as the other colours were visible.

2. A similar result was found when a green glass screen instead of a red was employed, the right eye being exposed in this case. The green sensation disappeared. The left eye was still partially red-blind, and the contrast between the spectrum as seen by it and by the right eye was very marked. Merely to look for a few seconds at a scarlet poppy in a corn-field causes a measurable degree of red-blindness for the next two or three minutes, and similar production of temporary green-blindness is observed in the case of persons who have been walking for a time in grass fields. J. J. S.

1640. *Theory of the Welsbach Burner.* **W. Nernst** and **E. Bose.** (Phys. Zeitschr. 1. pp. 289–291, March 31, 1900.)—That the temperature of a platinum wire when brought into a Bunsen flame is the higher the finer the wire, is not due to conduction, as shown by the fact that coils of thick platinum wire have the same low luminosity as simple loops. The temperature attained by the foreign body is the higher the quicker the heat is supplied to it, and the less the heat radiated by it. Carbon particles obey the laws of radiation of black bodies, and therefore emit infra-red heat rays to a great extent. A substance whose radiation was confined to the visible spectrum would be the ideal incandescent substance. It is probable that magnesium closely approaches this ideal state. The mantle of the Welsbach (Auer) burner also comes near it. By tracing the luminosity of the spectrum in terms of a normal incandescent lamp, and drawing the luminosity curves for incandescent lamps at various efficiencies and for the arc, a series of curves may be obtained which represent the radiation of carbon at various temperatures. The curve of the Welsbach burner shows a considerable falling off in the red portion, and, therefore, probably also in the infra-red region, when compared with the radiation of carbon. This means that much of the energy otherwise wasted in heat is utilised for increasing the luminosity, and this fact, together with the rapid acquisition of the temperature of the flame, accounts for the economy of the Welsbach incandescent light. E. E. F.

1641. *Phenomena of Polarised Light.* **N. Umow.** (Ann. d. Physik, 2. 1. pp. 72–77, May, 1900. From the Zeitschr. Phys. Chem. 30. p. 711, 1899.)—If a solid whose surface consists of a number of reflecting surfaces is placed in the path of a parallel beam of plane-polarised rays, the light reflected by it will in general fill a space of a pyramidal shape, with varying intensity. The minimum intensity will occur at those medial planes which contain the direction of vibration and the normal of the reflecting surface. This minimum will depend upon the size of the angle of polarisation at the limit of the body and the surrounding medium. In this manner colour phenomena can also be produced. Turbid media containing very small reflecting bodies suspended in them will show different colours in different directions. Such a suspended particle therefore plays the part of an analyser. The author describes an apparatus based upon these considerations, and suitable for the objective presentation of the general phenomena of polarised light. An electric lamp is furnished with a Foucault prism provided with a diaphragm with circular perforation. The image of the aperture is projected to a distance by means of a lens, and various substances are introduced into the path of the rays. A glass cone turned with its apex towards the source, and having its base in the focal plane, shows on a screen in the same plane a ring-shaped luminosity traversed by a black diameter. It thus acts as an analyser. A quartz-plate suitably cut gives a brightly-coloured pattern. A Babinet compensator gives coloured curves. If a quartz plate is introduced, and the beam is reflected downwards into a long vessel filled with a solution of cane sugar containing a few drops of an alcoholic solution of colophony, a spiral coloured beam is obtained, exhibiting the phenomenon of circular polarisation. As the beam descends, the colours become less vivid, owing to overlapping and absorption. E. E. F.

1642. *Conditions of the Stability of Optical Activity.* **J. A. Le Bel.** (Comptes Rendus, 130. pp. 1552–1555, June 5, 1900.)—The fact that certain asymmetric carbon and nitrogen compounds have not been obtained in an optically active form is explained by the instability of the latter and its consequent transformation into the enantiomorphic isomeride, this going on until complete racemisation takes place. The stability of such active molecules depends on the closeness of the contact existing between the separate radicles, and should hence be increased by an increase in the strength of the attraction exerted by the central atom on the different radicles, and also by an increase in the volume of the radicles. Thus for molecules like that of lactic acid in which the radicles are relatively small, the rotatory power readily disappears, whilst valerianic acid racemises with far less ease. On heating active amyl alcohol for forty-eight hours in sealed tubes, the author finds that the optical rotation decreases as the temperature rises; before heating, the rotation in a 22 cm. tube is — 8° 19′, and after heating at 50°, — 8° 1′; at 100°, — 4° 8′; at 150°, — 0° 47′; whilst after heating at 200° the alcohol becomes inactive. The tetra-substituted ammonium chloride, $NH(CH_3)(C_2H_5)(C_3H_7)Cl$, could not be obtained in an active form, but this is found to be possible with the compound, $N(CH_3)(C_2H_5)(C_3H_7)(C_4H_9)Cl$, and on heating at 50° a solution giving in a 50 cm. tube an initial rotation of — 2° 33′, the rotation decreases to — 2° 28′, whilst at 100° it becomes — 2° 20′; at higher temperatures the liquid becomes coloured. T. H. P.

1643. *New Analyser for Saccharimeter.* **F. F. Martens.** (Zeitschr. Instrumentenk. 20. pp. 82–85, March, 1900.)—This analyser, or instrument for measuring the rotation of the plane of polarisation, consists of two quartz wedges of equal angle, one right-handed and the other left-handed. These are turned with their two thick edges in the same direction and with the two outside faces parallel. Between the wedges is placed a glass wedge or prism, of such an angle that the deviation of a ray on passing through the glass equals the sum of the deviations in the two quartz wedges. The glass wedge is placed so that it deviates the ray to the opposite side from the quartz wedges and makes the total deviation zero. If a ray passes through equally thick parts of the right-handed and left-handed wedges no rotation will result, but if one wedge is moved relatively to the other a greater thickness of right-handed or of left-handed will result, and the corresponding rotation will be produced. The motions of the wedges are read off on scales. The analyser eyepiece contains the ordinary Nichol prism. The advantage of the arrangement is that the beam has the same rotation all over the field of view. J. B. H.

1644. *Prism of Uniform Dispersion.* **C. G. Abbot** and **F. E. Fowle, Jr.** (Astrophys. Journ. 11. pp. 135–139, March, 1900.)—The authors describe an arrangement in which prisms of different dispersions and different angles are combined in such a way as to give a spectrum in which equal increments of deviation correspond approximately to equal increments of wave-length. J. J. S.

1645. *Colour Photometer.* **F. F. Martens.** (Phys. Zeitschr. 1. pp. 182–183, Jan. 13, 1900. Read before the 71st Naturforscherversammlung in Munich.)—This is a spectro-photometer designed for comparing the absorptions of different solutions for the different lines of the spectrum. An ordinary spectroscope is used, and, in front of the slit, a compound prism similar to that used in the Lummer-Brodhun photometer is placed. One-half of the common hypothenuse-face of the two prisms is silvered, and the combination is placed in front of the slit so that one-half of the slit is illuminated directly by light which passes from the lamp through the unsilvered part of the hypothenuse, while the other half of the slit is illuminated by light from the same lamp, but which is reflected first from a mirror on to the silvered part of the hypothenuse-face and thence reflected on to the slit. The solutions to be compared are placed in suitable vessels in the two beams, and the thickness of one is adjusted until equality of spectral intensity is produced. To obtain an adjustable thickness of solution the reflected beam is made to pass vertically from one mirror to the other, and two glass vessels, one inside the other with the solution between them, are interposed in the vertical beam. By raising or lowering one of the vessels inside the other the thickness of the layer of solution is altered at will. J. B. H.

1646. *Absorption Spectra of Carbon Compounds.* **L. Puccianti.** (Phys. Zeitschr. 1. pp. 49–51, 1899.)—Monochromatic light obtained by means of a spectrometer was allowed to pass through the absorbing medium, and the intensity of the rays was then measured by a torsion-radiometer. The absorption spectra of benzene, toluene, orthoxylene, and methyl iodide were thus examined. Toluene has three absorption maxima in positions similar to those of benzene; it has, moreover, two strong absorption bands in coincidence with those of methyl iodide. The results are in agreement with the hypothesis that the absorption depends on the groups of atoms which exist in the molecule. J. J. S.

1647. *An Optical Illusion.* **C. H. Wind.** (Phys. Zeitschr. 1. pp. 112–113, 1899.)—The author describes a contrivance for exhibiting in a striking manner the optical illusion discovered independently by Mach and himself, which enabled them to refute the alleged production of interference fringes by Röntgen rays. Two slits are placed parallel to each other at a distance of 2 or 3 cm. The image of any source of light is projected on to the first slit so as to cover it completely, and the light penetrates the second slit and falls on a screen beyond, placed at a distance of 3 or 4 m. Now let the width of the first slit be gradually increased from zero, and let the second one be kept at a width of 2 or 3 mm. At first, true diffraction fringes appear, but afterwards a bright fringe begins to detach itself from each edge and to travel towards the middle. This fringe is entirely due to the optical illusion previously described [see Abstract No. 1871 (1899)]. When the two fringes coincide in the centre, there exists for the moment a true maximum of light. Another instance of the illusion is obtained when a needle or wire is substituted for the second slit. The bright lines travel outwards from the full shadow, and at a certain stage the latter appears doubled. The illusion can be destroyed by covering over the central portion with a suitable screen. Strict parallelism of the slits is essential to success. E. E. F.

1648. *Dual Nature of Radium Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1178–1179, April 30, 1900.)—An experiment is described which brings out clearly the heterogeneous nature of the rays given out by "radium" preparations. Radium rays are transmitted through a slit in a lead plate, and impinge at nearly grazing incidence upon two sensitive plates laid one over the other and wrapped in black paper. The rays are exposed to a strong magnetic field. It is evident that under these circumstances the upper plate receives rays which have traversed the black paper only, while the lower one receives rays which have traversed in addition the glass and film of the upper plate, and an increasing thickness of both as the angle of incidence increases towards the edge. On development the upper plate shows two impressions —one deviated and spread out, the other feebler, but absolutely rectilinear and sharp. On the lower plate only one impression is visible, that due to the non-deflected rays. The impression is as clear as that on the upper plate, and indeed clearer, if anything, owing to the absence of fog. A prolonged exposure brings out a very feeble indication of the deflected rays. A band of lead 0·3 mm. thick, laid across the upper plate, intercepts the deflected rays over its whole width, whereas the rectilinear rays are only weakened. Thus the two classes of rays may be distinguished from each other in the region where they are superposed. The author simply calls the two classes of rays X-rays and kathode rays. E. E. F.

1649. *Transparency of Aluminium to Radium Rays.* **H. Becquerel.** (Comptes Rendus, 130. pp. 1154–1157, April 30, 1900.)—Radio-active barium chloride fills a groove 1 mm. wide in a block of lead, which is placed between the poles of an electromagnet, so that the groove is parallel to the lines of force. A cylindrical copper bar 4 mm. diameter is placed 11·5 mm. above the groove and parallel to it, and at an equal distance above this is a photographic plate in a black envelope. In this way a shadow image is obtained, which may be displaced to the one side or the other by magnetic fields, in one direction or the opposite. When an aluminium plate, 0·1 mm. thick, is interposed above or below the copper bar, and inclined at 45°, the shadows have the same size, but are weakened by diffusion, and are not quite so far apart as before. The experiments made confirm his previous ones, and the author is opposed to Villard's conclusion that the rays which undergo deviation behave like kathode rays, and emerge normally to the plate traversed. G. E. A.

1650. *Radio-active Barium.* **B. v. Lengyel.** (Ber., 33. pp. 1237–1240, 1900.)—It is probable that all the radio-active "elements" which have been assumed to exist in conjunction with bismuth, lead, barium, and titanium are identical, since in every case pitchblende has been used as the crude material for their preparation. Ordinary barium has been rendered radio-active by heating the nitrate with uranylnitrate; the compounds prepared from this active material possess all the properties of the barium compounds in which the existence of "radium" has been postulated. It is therefore extremely unlikely that "radium" is a hitherto unknown element, for it would appear that the barium merely extracts the active material from the uranium, and that only one active material exists in the two preparations. T. M. L.

REFERENCES.

1651. *Spectra of Oscillatory Discharges.* **B. Hasselberg.** (Journ. de Physique, 9. pp. 153–155, March, 1900.)—Referring to the recent articles by G. A. Hemsalech on the variation of the spectrum of an oscillatory discharge produced by the introduction of self-induction into the circuit (Journ. de Physique, 3rd series, 8. p. 652, 1899; Comptes Rendus, 129. pp. 285–288, 1899; Science Abstracts, 1899, No. 1860), the author calls attention to previous work by Thaler and by Kirchoff many years ago. C. P. B.

1652. *Demonstration of Absorption Spectra.* **E. J. Formánek.** (Zeitschr. Instrumentenk., Beib. 5. pp. 41–43, March 1, 1900.)—Description of an arrangement for bringing a number of tubes containing different dye or salt solutions successively before the slit of a spectroscope. T. H. P.

1653. *Magneto-Optic Effects.* **W. Voigt.** (Phys. Zeitschr. 1. pp. 116–120, 128–131, 138–143, 1899.)—History of the Zeeman effect, with sketch of Lorentz's theory. G. E. A.

1654. *A New Refractometer.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 19. pp. 335–339, 1899.)—A description of a refractometer of variable refracting angle. The method depends partly on an application of total reflection, and is shortly defined as the method of grazing incidence and normal emergence. J. J. S.

1655. *Theory of the Microscope.* **K. Strehl.** (Zeitschr. Instrumentenk. 19. pp. 325–335, 1899.)—This is an elaborate mathematical paper on the formation of images in the microscope, supplementing a former investigation by the author. [See Abstract No. 1137 (1899).] J. J. S.

1656. *Colour Photography.* **J. W. Hinchley.** (Soc. Chem. Ind., Journ. 19. pp. 5–7; Discussion, pp. 7–8, Jan., 1900.)—After a brief survey of the progress of colour photography, the author describes in detail the manufacture of the ruled screens employed in the Joly process, mentioning the difficulties at first encountered, and the means adopted for overcoming them. G. H. B.

1657. *Zeeman Effect.* **H. A. Lorentz.** (Phys. Zeitschr. 1. pp. 39–41, 1899.)—A short discussion of the theories put forward by the author, and by Voigt, Poincaré and others, to explain the Zeeman effect, including the observed phenomena as to triplets and quadruplets. J. J. S.

HEAT.

1658. *Specific Heats of Fluids.* **E. H. Amagat.** (Comptes Rendus, 130. pp. 1443–1447, May 28, 1900.)—The author has plotted 44 isopiestics on a v-t diagram from the results of his experiments on CO$_2$, over a range of 1,000 atmospheres and between 0° and 260° C. From these curves he has obtained the values of $\partial v/\partial t$ for 25 temperatures, and has plotted the results with temperatures as abscissæ, and from these new curves he has obtained the values of $\partial^2 v/\partial t^2$ for these temperatures, and has plotted them with the corresponding *pressures* for abscissæ. Thence by simple quadrature he obtains the difference between the isopiestic specific heats for the same temperature and different pressures, since

$$J\,(\partial C/\partial p)_t = -t\,(\partial^2 v/\partial t^2)_p.$$

Quantitative results are reserved for future notes, but the curves show that for a temperature above the critical point, C increases with the pressure at first rapidly (especially for low temperatures) and then less rapidly, attaining a maximum value at a pressure, given by $\partial^2 v/\partial t^2 = 0$, which continuously increases with t and afterwards diminishes, at first rapidly and then less and less rapidly, as the pressure continues to increase: also that for a temperature below the critical point, C increases with the pressure till the state of saturation is reached, but then undergoes an abrupt change (the sign of which is not *à priori* assignable) and afterwards decreases indefinitely and less and less rapidly as the pressure continues to increase, so that its maximum value occurs when the vapour is saturated, and therefore at a pressure which increases with t as before. Further, that the maximum value of C is the greater the nearer the corresponding pressure is to the critical point, being infinite at the critical point; lastly, that for the gaseous state the variations of C decrease indefinitely as the temperature increases, becoming extremely small, and also, from and after a certain pressure for each temperature, they decrease indefinitely with increase of the pressure. A mode of calculating the abrupt variation of C accompanying the change of state is also given. R. E. B.

1659. *Limits of the Solid State. Part IV.* **G. Tammann.** (Ann. d. Physik, 2. 1. pp. 1–31; May, 1900.)—Last year (see 1899, Abstract No. 1693) the fusion curve of ice was traced up to pressures of 2,200 kg. per sq. cm. The author has since examined the region from 0° to — 80° under pressures of 1 to 3,200 kg., and two special areas, one from — 22° to — 15° under 3,200 to 4,000 kg., and another from — 80° to — 180° under 1 kg. per sq. cm. It appears that within these limits water can appear in four distinct states, termed by the author water, ice I, ice II, and ice III respectively. Ice I is ordinary ice. The transformation curves of ice II and ice III into ordinary ice are of special interest, since they are both retrograde, and each of them shares two temperatures of equilibrium under the same pressure. While the fusing curve of ordinary ice passes to lower temperatures under increased pressure, the fusing curves of the other two varieties pass to higher temperatures. To reach one of these fusing curves, an artifice is necessary. The temperature of ordinary ice must be brought below — 22°, and the pressure must be brought up to at least 2,400 kg. per sq. cm. If the temperature is reduced from — 30° to — 60°, ice III is obtained. At — 80° ice II is obtained. If now the volume is reduced until all the ordinary ice is transformed, an increase of temperature under a pressure of 2,500 kg. or more, yields one of the fusing curves, according to the kind of ice generated. The maximum transformation pressure of ice I into ice II is 2,252 kg. at — 34°, and the corresponding maximum for ice I into ice III is 2,255 kg. per sq. cm. at — 43°.

[In Ann. d. Physik, 2. 2. p. 424, June, 1900, the author states that the pressures in the above paper should have been put as kg. per sq. cm. instead of atmospheres. This correction has here been introduced.]

E. E. F.

1660. *Thermal Conductivity of Gases.* **E. Warburg and E. Gehrcke.** (Ann. d. Physik, 2. 1. pp. 102–114, May, 1900.)—If a gaseous layer is contained in the spherical shell between two concentric metallic spheres, convection is practically eliminated if the interval is small enough. If, therefore, the effect of radiation can be eliminated as well, it is possible to determine the thermal conductivity of the gas by observing the rate of cooling of the hotter inner sphere. This reasoning is, however, disturbed by the observation that when the pressure is reduced below a certain small amount, it begins to influence the apparent conductivity of the gas. This is explained by a discontinuity at the metallic surfaces, due to a discontinuity of temperature. The discontinuity of temperature may be defined by a length γ, such that at that distance from the wall the temperature would become equal to that of the nearest layer of the gas if the gradient were continuous. The virtual thickness of the gaseous layer is therefore increased by 2γ. If we suppose that γ is directly proportional to the mean free path λ, and therefore inversely proportional to the pressure, an explanation is furnished of the fact that the conductivity diminishes with the pressure at an increased rate the smaller the thickness of the gas layer. The authors determined the ratio γ/λ for air and hydrogen at low pressures, using co-axial cylinders of silvered brass instead of the glass tubes used by Smoluchowski. The cooling body was a mass of water contained in the interior cylinder. The ratio was found to be 1·83 in the case of air and 5·70 in the case of hydrogen. With increasing exhaustion, the ratio decreases after the mean free path has reached the value of 0·15 mm. In fact, the discontinuity of temperature tends to disappear when the molecules, owing to exhaustion or widening of the interval, acquire a certain freedom of motion. E. E. F.

1661. *Thermal Unit.* **E. Warburg.** (Phys. Zeitschr. 1. pp. 171–173; Discussion, p. 173, Jan. 6, 1900. Read before the 71st Naturforscherversammlung in Munich.)—After reference, historical and critical, to the establishment of the Regnault 0°–1° unit, the author considers that, in view of our knowledge of the change in the specific heat of water from 0° upwards, it is now necessary to redefine the unit of heat. Retaining the erg as theoretical unit, he gives the preference to a water calorie defined for a specific temperature as a secondary unit, and proposes to define the calorie as the quantity of heat that would raise a gramme of water from 14½° to 15½°. G. E. A.

1662. *Gibbs' Thermodynamic Model.* **W. P. Boynton.** (Phys. Rev. 10. pp. 228–233, April, 1900.)—Having found a difficulty in locating the directions of the axes in Maxwell's diagrammatic representation of Gibbs' model, the author has attempted, but without satisfactory success, to determine them by consideration of the properties of the critical state as given by van der Waals' characteristic. [But in his ϕ-v diagram he draws his dotted curve of saturation so that in the neighbourhood of the critical point there are two values of v for every one of ϕ. He also draws the isothermal for the critical temperature as thrice intersecting the isentropic through the critical point.] R. E. B.

1663. *Joule and Kelvin Effect.* **D. Berthelot.** (Comptes Rendus, 130. pp. 1379–1381, May 21, 1900.)—In previous papers (see Abstracts, Nos. 541 and 721, 1899) the author has given reasons for thinking that the Joule and Kelvin effect is closely connected with the values of pv/T; that, in fact, the maxima and minima of the isopiestics drawn with $y \equiv pv/\mathrm{T}$ for ordinate and T for abscissa give the temperatures of inversion of this phenomenon. Van der Waals' reduced characteristic, with v eliminated and $\psi \equiv \pi v/\tau$ introduced, becomes

$$(3\psi - 8)\,\psi^2\tau^3 = \pi\,(\psi^2\tau^2 - 9\psi\tau + 3\pi),$$

and gives

$$(3\psi - 8)\left\{(\psi\tau + 9)^2 - 108\tau\right\} = 0$$

for the locus of the maxima and minima points on the isopiestics. On this theory, therefore, the intersection of this curve by an isothermal gives the pressure for which the inversion occurs at the temperature corresponding to the isothermal, and its intersections by an isopiestic give the two temperatures of inversion for the corresponding pressure. This locus has a maximum ordinate (given by $\psi = 3 = \tau$) corresponding to $\pi = 9$, showing that at this pressure the two temperatures of inversion coincide, and that at pressures greater than 9 no inversion at all occurs. [On this theory the pressure for inversion at τ is $24\sqrt{(3\tau)} - 12\tau - 27$, and the temperatures for inversion at π are $\frac{1}{12}\left\{6 \pm \sqrt{(9 - \pi)}\right\}^2$.]

Amagat's curves for nitrogen differ considerably from those just discussed, but they indicate similar singularities, giving about 12 in place of 9 for the pressure above which no inversion of the sign of ψ occurs, and about 2½ in place of 3 for the coincident temperatures of inversion under this limiting pressure. [In the paper read 0·985 for 0·975.] R. E. B.

REFERENCES.

1664. *Specific Heat of Blood.* **H. Bordier.** (Comptes Rendus, 130. pp. 799–800, March 19, 1900.)

1665. *Comparison of Platinum and Gas Thermometers.* **J. A. Harker** and **P. Chappuis.** (Roy. Soc., Phil. Trans. 194. pp. 37–134, March 13, 1900.)—Full account of the investigation referred to in Abstract No. 637 (1900).

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1666. *Magnetic Field produced by Motion of an Electrified Body.* **V. Crémieu.** (Comptes Rendus, 130. pp. 1544–1549, June 5, 1900.)—According to Maxwell an electrified body in rapid motion should produce a magnetic field in its neighbourhood. Experiments made by Rowland in 1876, and by Rowland and Hutchinson in 1889, appear to have confirmed this. The author has repeated the test under more favourable conditions. Instead of observing, as Rowland did, the direct action of a revolving charged disc upon a magnetised needle, he has examined the inductive action of a similar disc upon a neighbouring circuit. A description (with figures) is given of the apparatus and method used; and the galvanometer readings calculated in accordance with theory are compared with those actually observed. The former should amount to 22·3 mm. with the lowest rates of revolution and superficial density of charge employed, and to 51·3 mm. with the highest. The actual readings lie between zero and 4 mm., and are stated to be due to unavoidable displacements of zero during the course of an experiment. The author concludes that the motion of an electrified body does not appear to produce any magnetic effect in its neighbourhood. D. E. J.

1667. *Imaginary Quantities and the Representation of Periodic Complex Functions.* **C. F. Guilbert.** (Écl. Électr. 22. pp. 405–414, March 17, 1900.) —The author's investigations are founded on a memoir by Steinmetz on the representation of vectors by imaginary quantities. He refers also to two memoirs by Janet [see Abstracts, Nos. 291 and 292 (1898)]. The object of the present paper is to extend Steinmetz's theory, which the writer says assumes that the periodic functions considered are sinusoidal, or can be replaced by equivalent sinusoidal functions. And this hypothesis fails in cases such as circuits containing capacities, or in which the resistances or self-inductions vary periodically. Steinmetz in a recent memoir has extended his theory, making use of the principle that when a non-sinusoidal tension acts on a circuit containing resistances, self-inductions, and capacities, each separate harmonic tension produces its full effect as if it had a circuit similar to the given one to itself. The author proceeds to explain that when the different harmonic tensions have different frequencies the terms under the symbol $\sqrt{-1}$ do not admit of being added algebraically, and this he shows by attaching an index to the symbol in the form $\sqrt{-1_n}$. In this memoir the equation—

$$I = \Sigma(i'_n + \sqrt{-1}_n i''_n) = \Sigma \frac{e'_n + \sqrt{-1}_n e''_n}{r + \sqrt{-1}\left(ns + s' + \frac{s''}{n}\right)}$$

signifies that for each value of n we have the equation—

$$i'_n + \sqrt{-1}_n i''_n = \frac{e'_n + \sqrt{-1}_n e'_n}{r + \sqrt{-1}_n\left(ns + s' + \frac{{}''s}{n}\right)}\,.$$

Steinmetz has given several examples of his method, two of which are worked out in detail by Guilbert. S. H. B.

1668. *Contact Force.* **O. J. Lodge.** (Phil. Mag. 49. pp. 351–383, April, and 454–475, May, 1900. Presidential Address to the Physical Society of London.)—The author endeavours in the first place to state the various views that are at present held as to the character of the contact electromotive force. The relations between the thermoelectric quantities, Π the coefficient of the Peltier effect, σ of the Thomson effect, and the electromotive force E, are clearly stated, it being shown that the thermodynamic equation

$$\Pi = T\frac{dE}{dT}$$

is in general only true for the whole of a closed circuit, and that Π is therefore not necessarily a measure of the electromotive force existing at a particular junction. Further, the view that the Volta contact force is the quantity whose differences and derivatives constitute the E.M.F.'s observed in thermoelectricity is regarded as an arbitrary assumption by the author, although one that may be true, since there is at present no disproof of it. In Chapter II. the facts of contact electricity are described, the main phenomenon being stated in the words "The Volta effect consists in an opposite charge acquired by dry zinc and copper while in metallic contact, a charge which results from an E.M.F. of value depending on the condition of their outer surfaces and controlled solely by this E.M.F. and the electrostatic capacity." Attempts have been made to relate this quantity to the heat of formation of brass from copper and zinc, but so far the evidence is too indefinite to draw any conclusions, but since no formation of alloy takes place when a current is passed across a junction, there seems no reason *à priori* to expect a relation.

In the fourth chapter the possible mechanism of the contact force is discussed. The author shows that to maintain his view that it is due to the action of oxygen on the two metals it is not necessary to assume any actual chemical combination, but only an extremely minute approach of the oxygen atoms towards the zinc, and a recession from the copper.

The customary electrochemical theory of the voltaic cell is then stated, and is followed by a discussion of the bearing of the electron theory on the production of electromotive force. It is suggested that conduction in the metals is due to passage of isolated charged corpuscles from one atom to the next; but this does not cause any chemical change, because, even if the conduction takes place across a junction between two metals, each atom on gaining one negative corpuscle loses a similar one, so that the amount of each metal remains the same. In electrolytes, however, the charged corpuscles drag their atoms (or groups of atoms) with them, so that chemical changes occur. The author then develops an ingenious theory (based, necessarily, however, on several unverifiable assumptions) as to the electromotive forces due to the movement of the corpuscles, following the analogy of Nernst's theory of diffusion cells, attributing to the charged corpuscles of opposite sign, definite mobilities u and v, *i.e.*, velocities under the influence of unit electric intensity. He obtains in this way a convenient expression for the various thermoelectrical quantities, arriving, *inter alia*, at the conclusions that the Hall effect ought to have the same sign as the coefficient of the Thomson effect, and that the thermoelectric power should be largest for metals of largest resistivity, as is actually the case. Helmholtz's view of a specific attraction of matter for electricity the author considers may be regarded as a primitive form of the electron theory. R. A. L.

DISCHARGE AND OSCILLATIONS.

1669. *Potential Gradient in Vacuum Tubes.* **H. A. Wilson.** (Phil. Mag. 49. pp. 505–516, June, 1900.)—The potential gradient and the conductivity of the gas in a vacuum tube is studied by a new probe which can be shifted into any part of the discharge at will. The discharge passes through a Torricellian vacuum, and an open glass tube containing the two electrodes floats on the mercury, whose surface can be raised or lowered by means of an indiarubber tube with thistle funnel. The upper electrode is connected with the outside by a flexible coil of thin brass wire.

Thus the vacuum tube proper floats up and down in the vacuum, and through the slit in its side the probes fixed into the side of the barometer tube are capable of entering. This arrangement secures a free displacement of the probes with respect to the discharge.

The author reproduces a number of diagrams showing the distribution of the potential gradient. There is a sudden drop of potential near the anode, often amounting to as much as 35 volts. The author confirms this by substituting mercury jets for the platinum probes, and attributes it to the great rate at which positive ions are shot off from the anode. He also studied the conductivity of the gas by means of the same probes, and obtained results generally confirming those of Stark [see Abstract No. 1459 (1900)]. E. E. F.

1670. *Luminous Effects on Wires Conveying Electric Discharges.* **J. Borgman.** (Comptes Rendus, 130. pp. 1179–1182, April 30, 1900.)—A metallic wire which is not covered by an insulating layer becomes covered with a luminous aureole when it is inserted in the circuit of an induction coil containing a spark-gap or a vacuum tube. The author has further investigated this phenomenon by means of wires sealed into cylindrical tubes, and traversing their axis. The tubes were several feet long and 3 cm. to 6 cm. wide. Some of the tubes were traversed by capillary glass tubes containing liquid conductors. As exhaustion proceeds, the luminous phenomena show a peculiar development. The aureole decreases in intensity, and is gradually replaced by a series of equidistant stars, around which luminous discs are formed with their planes at right angles to the wire. The number of stars and discs increases, until the latter touch each other and fill the whole tube with a luminosity having a slightly stratified aspect. These effects are the same whether the tube is attached to the positive or the negative terminal of the secondary. When a spark-gap is inserted in parallel with it, and the wire is attached to the negative terminal, there is only a continuous luminous envelope, which broadens out as exhaustion proceeds and finally detaches itself from the wire. The stars reappear on attaching the wire to the positive terminal, and at a certain pressure the discs reappear also, their diameter increasing with the length of the spark-gap. As exhaustion proceeds, the number of discs decreases, some of them remaining, while others disappear. Finally, they are transformed into nebulæ with a starry nucleus. The approach of a magnet has the effect of inclining the plane of the rings. E. E. F.

1671. *Powerful High-frequency Currents.* **d'Arsonval.** (Comptes Rendus, 130. pp. 1049–1054, April 17, 1900.)—A description of arrangements employed by the author in the decoration of the façade of the Palace of Electricity at the Paris Exhibition of 1900. Highly luminous and very brilliant sparks were required, some to be short and others much longer. To produce these the discharge of powerful condensers has been employed, these latter being charged by transformers at high potential actuated by alternators. A description is given of the transformer, condenser, exploder, and transforming coil. The transformer is of the Labour type with closed magnetic circuit. It can absorb up to 30 kilowatts. The condenser, after trial of many substances, was finally made with micanite as insulating material, with sheets of tin-plate. The micanite is formed by gluing together when hot, with gum lac and under high pressure, very thin sheets of mica. The whole is plunged in a glass vessel containing ordinary petroleum, which acts as an excellent insulator. The condenser thus formed behaves admirably : there is no heating, as there is no electrolysible substance. The discharge spark of the condenser takes place between two balls. A continuous arc is formed which can be blown aside by a magnetic field, but preferably by a jet of air. The rotatory exploder has been devised to get a convenient means of blowing the spark. Two metallic rods with spheres at their ends are made to rotate rapidly, describing in air a circumference whose diameter varies in different cases from 30 cm. to 200 cm. and more. Thus a strong wind is produced between the balls simply by their displacement in air with an insignificant expenditure of energy. When in these circumstances the spark passes a very interesting luminous phenomenon is produced ; the effects resembling those obtained with a revolving mirror, but being much more luminous. The author's transforming coil, by which the long sparks required are obtained, is next described. The arrangement is similar to that used by Elihu Thomson. The induced and inducing circuits are concentric and immersed in a vessel of oil. Long and brilliant sparks are obtained, and the length can be increased several times by making them pass to plates of marble covered with thin sheets of metal, preferably zinc. J. J. S.

1672. *Discontinuities in the Laws of Electric Discharge in Gases.* **W. Kaufmann.** (Ann. d. Physik, 2. 1. pp. 158-178, May, 1900.)—A continuous change of any of the elements governing a vacuum discharge, such as the E.M.F., the external resistance, the temperature, or the pressure, often produces a sudden and discontinuous change in the current strength and the potential gradient, usually characterised by a change in the appearance of the discharge. The author investigates the relations which must exist between the variables in order that a given current should be stable.

The relation between the stationary current J and the difference of potential E at the ends of the gaseous conductor may be expressed by an empirical curve of the form—

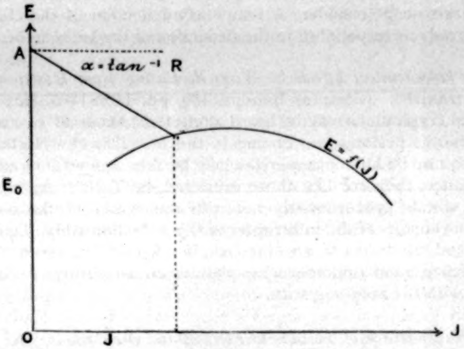
$$E = f(J)$$

which may be termed the "characteristic curve" of the gaseous conductor. Any one of the indefinite number of pairs of values of E_0 and R (the total resistance) belonging to a given current J may be calculated from the equation—

$$E_0 - JW = E = f(J)$$

If $f(J)$ is not given as an equation, but as a curve, it will as a rule be most convenient to solve the equation graphically. For this purpose, J is entered as an abscissa and E as an ordinate in a rectangular system (see diagram). Through the proper point of the curve $E = f(J)$ a straight line is drawn which may intersect the axis of ordinates in A. Then if $E_0 = OA$ and

$R = \tan \alpha$, the above equation is fulfilled, and E_0 and R are one of the pairs of values sought. The author shows that they are stable if the line $E_0 - JW$ is tangent to the characteristic curve, and illustrates this rule by



reference to the transition from the spark discharge to the glow discharge and the arc discharge. E. E. F.

1673. *Current at Break.* **K. R. Johnson.** (Ann. d. Physik, 2. 1. pp. 179–185, May, 1900).—The author objects to Arons' theoretical treatment of the current at break, given in 1897, that owing to the transition resistance at the surface of the metal there is no continuous increase of resistance to infinity at break, as assumed by Arons. He substitutes another treatment, which gives the conditions under which the spark at break can be avoided. He comes to the conclusion that the current at break is essentially a transformation of the electric energy of the circuit into Hertzian waves. The wave train is suddenly terminated when the spark passes. E. E. F.

1674. *Transient Deflection of Kathode Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1177–1178, April 30, 1900.)—In 1896, G. Jaumann described what he believed to be a peculiar property of kathode rays. He immersed a very highly exhausted vacuum tube in ordinary vegetable oil. The tube was provided with a single electrode, which served as a kathode, while the anode was outside the tube and in the oil. When the tube was working the approach of a charged glass rod apparently produced a repulsion of the beam of kathode rays and the fluorescent spot produced by it. This repulsion rapidly subsided while the glass rod was held in the same position. When the rod was removed, or when the charge was of the opposite sign, the repulsion became an attraction. The author has repeated the experiment and verified the effects as stated, but he does not follow Jaumann in ascribing them to a peculiar property of the kathode rays, such as the "self-stretching" property which the latter connected with his hypothesis of "longitudinal light." The author points out that commercial oils are very poor insulators, whereas true dielectrics have been shown by Bouty to intercept an electrostatic field as effectively as a layer of mercury. Consequently the electrostatic field produced in the interior of the tube by the glass rod outside depends upon the conductivity of the oil, and if the oil takes some time to adjust itself to an external field, there will be an electrostatic process within the oil which may well last a second. Such a process would explain the temporary deflection of the kathode beam described. In confirmation of this explanation the author replaces the kathode beam by a conductor joined through a screened wire with an electroscope outside. A temporary deflection of the electroscope is then observed, corresponding to the deflection of the kathode beam. E. E. F.

1675. *Photochemical Effects by Wires Radiating from Hertzian Oscillators.* **T. Tommasina.** (Comptes Rendus, 130. pp. 1462–1465, May 28, 1900.)—Rhythmical crepitations may be heard along the "antenna" or radiating wire which forms the prolongation of one of the branches of a Hertzian primary. In the dark, mobile luminous *aigrettes* may be seen around the radiating wire. In appearance they are like those exhibited in Tesla's experiments; they appear to vibrate synchronously, not with the sparks of the oscillator, but with the movements of the interrupter of the induction coil. They cannot be photographed by means of an objective, but figures are given showing the effect produced upon a photographic plate when its sensitive surface is placed in contact with the radiating wire. D. E. J.

1676. *Transparency of Liquids to Electrostatic Oscillations.* **A. de Heen.** (Comptes Rendus, 130. pp. 1460–1461, May 28, 1900.)—The oscillations are produced by connecting *one* of the poles of an induction coil with a metallic conductor. The liquid to be examined is placed in the annular space between two concentric test-tubes. Water, alcohol, aldehyde, and carbon bisulphide are found to be opaque; ether, petroleum, benzene, xylene, butyric acid, and valerianic acid are transparent. D. E. J.

1677. *Energy of Streams of Electric Waves.* **C. Heinke.** (Phys. Zeitschr. 1. pp. 197–200, Jan. 27, 1900. Paper read before the 71st Naturforscherversammlung in Munich.)—The author discusses the various methods of measuring the energy of electric oscillations, with reference to investigations of his own (Elektrotechn. Zeitschr. 20. pp. 510–513 and 527–531, 1899), and finds that the instruments usually employed, viz., galvanometers, Weston and d'Arsonval instruments, &c., give unsatisfactory results. He shows that the instantaneous force may have the opposite sign to that usually attributed to it. His own method is described by the aid of diagrams. In conclusion he maintains that the only instrument which gives the true energy of an electric wave system is the wattmeter; and if that be not obtainable the only trustworthy method is the complete conversion of the energy into heat and its calorimetric measurement. S. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1678. *Hysteresis and Viscosity of Dielectrics.* **F. Beaulard.** (Comptes Rendus, 130. pp. 1182–1185, April 30, 1900.)—Arno has shown that a dielectric placed in an alternating electrostatic field gets heated, and that the heating is proportional to some power of the E.M.F. Similarly, Janet has proved that with increasing potentials the charge of a condenser is feebler than it is when the potentials are decreasing. This lag is due either to viscosity or to hysteresis. Arno supports the latter alternative. In that case the dissipation of energy should be independent of the rate at which a cycle is completed. The author's experiments, however, point to the opposite conclusion. He charged a condenser to the same potential during various time intervals ranging from 4 seconds to 600 seconds, and compared the charges by sending them through a ballistic galvanometer. He found that the loss of energy in the condenser decreased as the time increased, and that if the process of charging the condenser was extended over an interval of fifteen minutes the loss was nil. He therefore concludes that the effect is due to viscosity rather than hysteresis. E. E. F.

1679. *Conductivity and Permeability of Iron Alloys.* **W. F. Barrett, W. Brown,** and **R. A. Hadfield.** (Roy. Dublin Soc., Proc. 7. pp. 67–126, Jan., 1900.)—The authors determined the electric conductivities and magnetic permeabilities of over a hundred alloys of iron manufactured at the Hecla Steel Works, Sheffield. The specimens are divided into three classes. The first class consists of alloys containing one constituent besides iron, and comprises carbon, manganese, nickel, tungsten, aluminium, silicon, chromium, and copper "steels." The second class contains two admixtures, the main admixture consisting of nickel, manganese, chromium, or aluminium. The third class contains three or more admixtures. As regards conductivity, the authors conclude that (1) in all cases a larger, and in some of the alloys a very much larger, increase in electric resistance is produced by the first additions of the added element than for similar amounts added after the alloy is rich in that particular element; (2) the increase in the electric resistance of iron produced by alloying it with an equal percentage of different elements varies through a wide range, according to the nature of the added element, but this increase of resistivity does not appear to be connected with the specific resistance of the added metal; (3) taking the specific electric resistance of mild steel, or of iron containing approximately the same amount of impurities as are present in the alloys tested, to be about 15 microhms per c.c. at the temperature of the air, then the addition of corresponding amounts (say 3 per cent.) of the following metals raises the resistance in the case of annealed alloys of iron and

3 per cent. of	Tungsten	to about	17,	or an increase of	2	microhms.
,,	Nickel	,,	21	,, ,,	6	,,
,,	Chromium	,,	24	,, ,,	9	,,
,,	Manganese	,,	30	,, ,,	15	,,
,,	Silicon	,,	45	,, ,,	30	,,
,,	Aluminium	,,	48	,, ,,	33	,,

Among a large number of valuable results may be mentioned the discovery of a nickel-manganese steel having a specific resistance of 97·52 microhms per c.c. at 15°, probably the highest resistivity of any metallic conductor yet obtained as wire in a commercial form. It is sixty times greater than the resistivity of pure copper, nearly ten times as great as that of the best iron, and 4½ times greater than that of German silver. The alloy contains 25 per cent. of nickel, 5·04 of manganese, and 0·6 of carbon.

In the second part of the paper, dealing with the magnetic properties of the various specimens, the most remarkable result is the effect produced upon iron by the addition of silicon. The addition of 2 to 5½ per cent. of silicon to steel increases the magnetic softness to such an extent that the coercive force and retentivity are reduced to nearly one-half of the standard iron rod, which contains only 0·03 per cent. of carbon. The permeability is also higher than that of iron for magnetising forces below saturation. E. E. F.

1680. *Thermo-electricity of Oxides and Sulphides.* **A. Abt.** (Ann. d. Physik, 2. 2. pp. 266–279, June, 1900. Paper read before the Hungarian Academy of Science, Dec. 18, 1899.)—The author combines various metals with a number of oxides and sulphides, and discovers some thermoelectric couples of very high E.M.F. The resulting figures are given on an arbitrary scale, in which the E.M.F. of a bismuth-antimony couple with its junctions at 98·1° and 1·4° respectively appears as 200. Under the same circumstances, the following E.M.F.'s are obtained (in arbitrary units) :—

Pyrolusite-Bismuth	210·6	Chalcopyrite-Bismuth	542·2
Pyrolusite-Antimony	396·9	Chalcopyrite-Antimony	669·3
Pyrrhotite-Antimony	21·7	Pyrite-Pyrolusite	933·2
Pyrrhotite-Bismuth	178·0		

The highest value obtained is that of the couple Pyrite-Chalcopyrite, whose E.M.F. is 7·62 times that of the bismuth-antimony couple. E. E. F.

1681. *Thermoelectric Properties of Alloys.* **É. Steinmann.** (Comptes Rendus, 130. pp. 1300–1303, May 14, 1900.)—The results are given for the E.M.F. between 0° and 100° of couples formed of chemically pure lead and the following alloys : Ten nickel-steels, four platinum-iridiums, three aluminium bronzes, five telegraph bronzes, five brasses, and four German silvers. The E.M.F. was measured by a modified Poggendorff compensation method, the curve being determined for five temperatures of the hot junction. G. E. A.

1682. *Earth Resistance of Lightning Conductors.* **R. Nowotny.** (Zeitschr. Elektrotechn. Wien, 18. pp. 279–281, June 3, 1900.)—In the case of lightning conductors whose upper portions are in connection with any conducting masses attached to, or on the roof of, the building, it becomes necessary, in testing the resistance of the earth connection, to provide some method of entirely disconnecting the lower earthed portion of the conductor from its upper portion, which is indirectly earthed on account of being connected to metal work about the building. For the purpose of enabling this test to be carried out, it has been usual to specify—notably in the case of conductors attached to derricks supporting telephone wires—a coupling by means of which the upper portion of the conductor could be disconnected when carrying out the earth test. The author describes a method devised by E. Ruhstrat which enables the coupling to be dispensed with. The method is a modification of a Wheatstone's bridge, alternating currents being employed. Three measurements are necessary ; the first gives the ratio of the two earth resistances corresponding to the upper and lower portions of the conductor respectively, while the other two, in which an auxiliary independent earth connection is used, supply two further equations for determining the absolute values of the quantities required. In the first test a portion of the conductor about 1 metre long is made to form a diagonal of the Wheatstone's bridge, and has a telephone receiver connected across it. A. H.

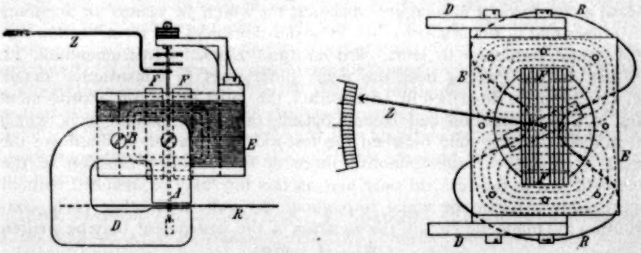
1683. *Testing in Cable Factories.* **H. W. Fisher.** (Elect. World and Engineer, 35. pp. 701–703, May 12, 1900.)—Diagrams of a special testing set are given whereby a switch having five positions enables the following five readings to be immediately taken : Condenser constant, cable capacity, cable resistance, resistance constant, and Wheatstone's bridge. The galvanometer is hung on springs loaded with 500 lbs. supported on a pneumatic cushion.

A megohm is permanently in series with the cells when testing insulation, and 40,000 ohms when testing capacity. A small thermal cell provides current for checking the galvanometer deflection. M. O'G.

1684. *Variations of Clark Cells.* **A. P. Trotter.** (Phys. Soc., Proc. 16. pp. 496–504; Discussion, pp. 505–508, 1899.)—A number of Clark cells by different makers are compared among themselves periodically by means of a Crompton potentiometer, with a view to setting up a commercial standard for Cape Colony.

Curves are given, showing the variations of six Muirhead cells and two Wolff cells from a seventh Muirhead cell taken as standard. The internal resistance of the Muirhead cells was measured by finding the galvanometer deflection for a given displacement of the potentiometer slider. G. E. A.

1685. *Alternate Current Instruments.* **G. Benischke.** (Elektrotechn. Zeitschr. 21. pp. 399–401; Discussion, pp. 401–403, May 17, 1900.)—The instruments described and illustrated in this paper are designed to indicate accurately with both direct and alternating currents, and are made by the Allgemeine Elektricitäts-Gesellschaft. They are all dynamometric, and magnetically damped. The essential parts of the instruments are shown in the figure for the voltmeter, in which E is a piece made of laminated iron having an aperture in the middle limited by circular arcs. The stationary coil F is mounted in this aperture, and in the stationary coil is arranged the movable coil on its arbor A. On this arbor there is also the pointer Z and the double aluminium blade R, the outer edges of which move between the poles of the two damping-magnets D, D. The iron E is so arranged that it takes up practically all the lines of force generated by the coils, so that the damping-magnets are not influenced thereby. The fixed and moving coils are of copper wire (130 ohms together), and are arranged in series with each other and with a resistance (2,000 ohms) for an instrument reading to 125 and 250 volts. In the wattmeter the fixed series coil is made with two windings, the four ends of which are brought to the four blocks of a plug-switch, so that they can be arranged in series or in parallel as desired. The readings are rendered independent of the difference of phase between the pressure and current by making the correction factor in Stefan's formula unity. This formula is as follows: $L = C\frac{1+\tan^2\psi}{1+\tan\phi\tan\psi}$, where L = energy; C = energy when the current is exactly in phase with the pressure; ϕ = the angle expressing the difference of phase between the current and pressure in the main circuit; and ψ = the angle expressing difference of phase in the shunt



of the wattmeter. The desired result is obtained when $\tan\psi = 0$. Now $\tan\psi$ is the ratio of the inductive resistance to the ohmic resistance in the shunt coil of the wattmeter, and this ratio $= 0$ when the inductive resistance is negligible relatively to the ohmic. For the same reason the instrument is practically independent of variations of periodicity. The magnetisation of the iron is so low that there is no appreciable hysteresis effect. In the ammeter the fixed coil is traversed by the current to be measured, and the movable coil is arranged as a shunt to a resistance in series with the fixed coil.

In the discussion **A. Franke** questioned the expediency and also the possibility of making a wattmeter which would indicate correctly with differences of phase amounting to 80°. He also mentioned that he had not been able to obtain aluminium sufficiently free from iron to be applicable for use in magnetic fields. The author in reply stated that in calibrating with direct and alternating currents there was only a difference of 0·2 per cent. in the ammeter and a difference of less than 0·5 per cent. in the wattmeter.

C. K. F.

1686. *Magnetic Balance.* **H. du Bois.** (Zeitschr. Instrumentenk. 20. pp. 113–121, April, and pp. 129–140, May, 1900.)—The author describes in full detail a new form of his magnetic balance, for which he claims an accuracy five times that of the original type. (For description of old form, see Ewing's "Magnetic Induction in Iron," 3rd ed., and Zeitschr. Instrumentenk. 12. p. 404, 1892.) Passing over the many differences in constructive detail, which cannot be described in an Abstract, the most important improvement lies in a compensation coil wound outside the main exciting coil, which neutralises the stray field between the test-rod and the outer windings; the result is that the magneto-motive force of the coil is a function of the magnetic flux in the test-rod only, and as this flux may be assumed without appreciable error to be equal throughout the yoke and other parts constituting the magnetic circuit, the equation of the instrument may be written

$$f(\mathbf{B}) = \dot{\mathbf{H}} - F(\mathbf{B})$$

where $f(\mathbf{B})$ is the magnetic force in the test-rod and $F(\mathbf{B})$ that in the rest of the circuit. This latter function then depends only on the instrument, and is independent of the material of the test-rod. The curve $\mathbf{H} = F(\mathbf{B})$ is given with the instrument, and, if traced together with any $\mathbf{BH}$ curve measured by the balance, represents the new ordinate from which the abscissæ $\mathbf{H}$ are to be measured to give the curve of the test-rod.

The test-rod, of either round or square section, must be given a sectional area of 0·5 cm.^{2}; its length between the clamps is 25·2 or 8π cm. It may be fixed in two ways; either a rod 33 cm. in length is held between clamps as in the old balance, or, preferably, a rod 25·4 cm. in length is given hemispherical ends, which fit into hemispherical cavities in two blocks which take the place of the clamps. Besides self-centring the test-rod, this method has the advantage that the junction forms a nearly equipotential surface of the diverging lines of force, and therefore diverts them less than any other from their direction through a perfect junction, with the result that the correction for the spreading out of the lines of force remains constant, whatever be the relative permeabilities of the test-rod and blocks.

For use with short test-rods, 2π or 6·3 cm. in length, conical filling-pieces are provided with a special exciting coil. The exciting coil, used with test-rods of normal length, is wound with 14 layers of wire of 200 turns each, the two outer layers being wound in the contrary direction and serving as the compensation winding already mentioned; the effective exciting turns are therefore 2,000. The maximum permissible current is 5 amperes.

The upper part of the yoke has two quadratic scales for use with a light and heavy sliding weight, giving two ranges of induction up to and above 5,000 c.g.s. units. The readings, multiplied by 100, give the induction directly in c.g.s. units. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1687. *Variation of Condenser and Choking Coil Currents with the Shape of the Applied E.M.F. Wave.* **A. Russell.** (Inst. Elect. Engin., Journ. 29. pp. 154–168, Jan., 1900.)—This is a mathematical investigation of the effect of different wave forms of applied E.M.F. on condensers and choking coils.

Curves of various families are considered, and the author draws the following conclusions: (1) A knowledge of the effective currents produced in a condenser and a choking coil by a given alternating E.M.F. gives practically very little information about the shape of the wave. (2) The "form factor" is not a suitable name for the ratio $\frac{V}{v_m}$, where V is the effective voltage and v_m its mean value. It would be better to call it the "area-factor" or the "hysteresis factor." (3) The sine curve wave applied to a condenser produces a smaller effective current than any of the other curves considered. If this current is not the smallest produced by any wave it must be something very nearly equal to the absolute minimum. (4) The sine curve wave applied to a choking coil produces a larger magnetising current than any of the other waves considered. (5) In a family of waves of equal height the symmetrical wave produces the maximum choking coil current and the minimum condenser current. W. G. R.

1688. *Magnetic Tests of Sheet Iron.* **J. Epstein.** (Elektrotechn. Zeitschr. 21. pp. 303–307, April 19, 1900.)—To find the hysteresis and eddy losses, strips are cut from the sheet and are made up into four equal bundles, with paper insulation. Each bundle has a magnetising coil slipped on, and the four are fixed firmly together in the shape of a square. An alternating voltage is applied to the choking coil thus formed, and the combined losses are found in the ordinary way by a wattmeter for any desired values of the magnetic induction and the frequency. By using different frequencies the losses can be separated. The losses being given in the form $\eta n B^{1{\cdot}6}$ and $f n^2 B^2$, the value of η, in some results quoted, ranges from 0·00136 to 0·00191; and f for a certain sample varies from 4×10^{-7}, for sheets 0·4 mm. thick, up to 16×10^{-7} for sheets 0·92 mm. thick. The method is advocated for general commercial use. **F. Niethammer** (Elektrotechn. Zeitschr. 21. pp. 361–362, May 3, 1900) comments on the above paper. W. H. E.

1689. *Relation between Magnetic Disturbance and Sun-Spot Frequency.* **W. Ellis.** (Roy. Astro. Soc., Monthly Notices, 60. pp. 142–157, 1899.)—In this paper the author continues the investigation referred to in Abstract No. 898 (1898). By comparing the curves furnished by the Greenwich magnetographs and the values of the sun-spot frequency, as tabulated by R. Wolf, he concludes that unusual magnetic disturbance is frequent about epochs of sun-spot maximum, and nearly or quite absent about epochs of sun-spot minimum, the general rise and fall in the number of days of great and active disturbance concurrent with variation in sun-spot frequency being fairly clearly shown by means of a curve. In the approach towards sun-spot minimum there usually comes a time at which great disturbance ceases, while instances of moderate disturbances continue to occur; these ultimately also cease at sun-spot minimum. After passing this minimum the disturbances are quickly renewed, the renewal being much more rapid than was the dying down.

The author also considers the variation in the frequency of magnetic disturbance with the time of year, and concludes that the larger disturbances are more frequent in spring and autumn than in summer and winter. The magnitudes of the spring and autumn maxima appear to be about the same, while the winter minimum is a little better marked than is the summer one.

W. W.

REFERENCES.

1690. *Measuring Instruments.* **H. Armagnat.** (Écl. Électr. 23. pp. 130–140, April 28, 1900.)—An article dealing with various patent specifications, and illustrated by the patent drawings. The instruments include the Addenbrooke electrometer, Blackburn and Spence's galvanometer, Crompton voltmeter, Heap voltmeter, Davis and Conrad's galvanometer, and others.

1691. *Ammeter with Long Scale.* **B. Davies.** (Phys. Soc., Proc. 16. pp. 425–434; Discussion, pp. 434–435, 1899.)

1692. *Magnetic Analogue of the Coherer.* **G. Vassura.** (Rivista Sci.-Industriale, 32. pp. 17–20, Jan. 30, 1900.)—An attempt to trace out an analogy between the action of a coherer and the behaviour of soft iron in the magnetic field. An observation made by Ewing on the behaviour of a *closed circuit* soft iron ring is quoted as if referring to a soft iron *bar.* R. N. L.

1693. *Effect of Heat on Vacuum Discharges.* **G. C. Schmidt.** (Ann. d. Physik, 1. 4. pp. 625–647, April, 1900.)—A paper similar to that referred to in Abstract No. 1071 (1900). E. E. F.

1694. *Ionisation of Gases.* **Langevin.** (Soc. Franç. Phys., Bull. 148. pp. 11–12, May 4, 1900.)—This is a summary of known facts and current theories.

E. E. F.

1695. *Compensation of Errors in Wattmeters.* **L. Kallir.** (Zeitschr. Elektrotechn. Wien, 18. pp. 233–236, May 6, 1900.)—The ordinary wattmeter can be connected in a circuit with the shunt coil attached either between the series coil and the apparatus taking power, or to the other end of the series coil. In the first case, the current through the series coil is too great by that flowing through the shunt, and in the second case, the volts on the shunt are too great by those on the series coil. The author proposes to compensate the error by introducing a second fixed coil.

G. H. B.

1696. *Measuring E.M.F. of Polarisation.* **E. Müller.** (Zeitschr. Elektrochem. 6. pp. 543–547, May 3, 1900.)—The method here used to study the relationship between a gradually increasing E.M.F. applied to an electrolytic cell and the currents produced is specially suited to chemical laboratories and other places where the delicate galvanometer necessary to measure the small currents is not readily obtainable. The only instruments used are two special rheostats and a capillary electrometer. A diagram of connections and other particulars together with the results of some experiments, are given in the paper. J. B. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1697. *Modern Explosives.* **W. Macnab** and **E. Ristori.** (Roy. Soc., Proc. 66. pp. 221–232, April 14, 1900.)—The authors are carrying out a series of experiments to determine the actual maximum temperature reached during the explosion of various explosive materials in a closed vessel. For measuring the temperature they use the pyrometric method developed by Roberts-Austen, modifications being introduced to overcome the difficulties of the very high temperature, the extreme shortness of duration of the maximum temperature, and the necessity of carrying out the explosion in a closed space. The calorimetric bomb employed is similar to that already described by the authors, with the addition that in the lid are inserted two insulated conical pins, one of pure platinum and the other of platinum alloyed with 10 per cent. of rhodium. The pins are connected on the outside of the lid with the terminals of the galvanometer, and on the inside with the platinum and platinum-rhodium wires constituting the thermoelectric couple; the portions of the wires in contact are fused together and the junction drawn through a die so as to make it of the same diameter as the rest of the wire. The photographic method of recording the temperature is made use of, the couple being placed in that position of the bomb which is found experimentally to give the greatest and most uniform deflection of the galvanometer. The results of a series of experiments with 10 couples of varying cross-section are given, and show that for cross-sections greater than about 0·00037 square inches in area, the deflection of the galvanometer is inversely proportional to that area; with thinner couples a greater deflection is obtained than would correspond to a straight line law. The deflection for an infinitely thin couple, which would take up instantly the high temperature obtained in the bomb, can hence be deduced and would correspond to the real maximum temperature. The general uniformity of the results obtained by the authors is shown by the following table, which gives the deflections produced with different couples, the charge consisting of 4 grammes of Ardeer Ballistite, containing 70 per cent. gun-cotton and 30 per cent. nitro-glycerine.

Area of section of couple in square inches.	Deflection on Scale in mm.	
	Mean of several readings.	Maximum.
0·00152	83	85
0·00125	97	102
0·00099	112·5	115·5
0·00061	132·5	138·5
0·00053	148	149
0·00037	154	158·5
0·00025	165·5	170
0·00017	189	192

It is found that, within reasonable limits, the size of grain of the explosive exercises no influence on the deflection obtained. Experiments with gun-cotton, cordite, and ballistite show that the lowest temperature is that yielded by gun-cotton, and that with ballistite the temperature reached is higher as the proportion of nitro-glycerine increases; cordite, although it contains 58 per cent. of nitro-glycerine, yet, on account of the vaseline present, gives a temperature lower than ballistite containing only 30 per cent. of nitro-glycerine, but no vaseline. The results obtained up to the present are purely comparative, and experiments are now in hand for the purpose of determining the value of the galvanometer deflections in degrees of temperature.

T. H. P.

1698. *Nature of Colloidal Solutions of Metals.* **R. Zsigmondy.** (Zeitschr. Phys. Chem. 33. pp. 63–73, April 3, 1900.)—This is a criticism of a paper on the above subject published by Stoeckl and Vanino. The conclusion arrived at by these investigators, *i.e.*, that the so-called colloidal solutions of metals are merely suspensions, is vigorously contested. It is maintained that the optical test is of no value, since only those solutions will be optically "empty" that have the power of precipitating all insoluble impurities. Moreover, the light may be reflected from still undissolved solid particles of a substance, the greater part of which is really dissolved. The author regards colloidal solutions as real solutions, *i.e.*, as homogeneous mixtures, and sums up the characteristics of such solutions. They exhibit in general some osmotic pressure and power of diffusion. Many of them can be considerably concentrated without undergoing apparent change. When the solvent freezes completely the colloids separate, many of them in an insoluble form. They cannot be separated by decantation or filtration through paper-filters, though some can be separated by porous earthenware. To prove the existence of a "suspension," it is necessary to show that the greater part of the substance is present in the liquid in the *solid* state. That "colloidal" gold solutions give a diffusely reflected light which is elliptically polarised, are precipitated by animal charcoal, and behave towards the electric current like suspensions, is not regarded by the author as conclusive proof that they are suspensions.

F. G. D.

1699. *Influence of Salts on Solubility.* **V. Rothmund.** (Zeitschr. Phys. Chem. 33. pp. 401–414, May 18, 1900.)—The question of the diminution of the solubility of non-electrolytes in water by the addition of various salts is theoretically discussed, and some experiments with phenylthiocarbamide, made with a view to elucidate the problem, are described in detail. From the results obtained and from analogous experiments recorded by previous observers, it appears that the solubility of phenylthiocarbamide is usually greatly diminished by the presence of salts, sulphates and carbonates being the most, and nitrates the least, active in this respect. The solubility is practically uninfluenced by the nitrates of lithium and barium, and is slightly increased by ammonium nitrate. The order of activity of various salts is the same as in the case of carbon dioxide, hydrogen, nitrous oxide, and ethyl acetate. The relative change of solubility is independent of the temperature; hence it follows that the heat of solution of the substance in water is the same as in the salt solution. This seems to indicate that the decreased solubility is due not to a reaction between the substance and the dissolved salt—which would be accompanied by some heat effect—but to some action of the salt on the water.

N. L.

1700. *Solidification and Transformation of Mixtures of Optical Isomerides.* **J. H. Adriani.** (Zeitschr. Phys. Chem. 33. pp. 453–476, May 18, 1900; see also 1900, Abstracts Nos. 678, 679, 680.)—In the earlier part of the paper the methods that have been suggested for detecting the existence of racemic compounds in the solid, liquid, and gaseous states are criticised, and it is shown that the only reliable method is that suggested by Roozeboom [see 1899, Abstract No. 1210] of examining a complete series of mixtures of the two optical isomerides. This has been done in the case of the substances described below.

(1) The melting-point curve of the dimethyl tartrates falls from 43·3° (the m.p. of the separate isomerides) to two eutectic points at 41·6° (the m.p. of a mixture containing the two isomerides in the proportion of 1 to 99 per cent.), and then rises to 89·4° in an inactive mixture of equal parts of the two isomerides. The substances thus show the characteristic behaviour of optical isomerides which give a well-defined racemic compound.

(2) Dimethyl diacetyltartrate shows a similar behaviour, but the m.p. of the racemic compound (83·8°) lies below that of the separate isomerides (104·3°); the eutectic points are at 83·4° in mixtures containing the isomerides in the proportion of 45 to 55 per cent.

(3) Mandelic acid resembles the preceding compound, the active forms melting at 132·8°, the racemic compound at 118°, whilst eutectic points occur at 113° in mixtures containing 40 and 60 per cent. of the two isomerides.

(4) The active benzoyltetrahydroquinaldines melt at 119·4°, and the racemic compound at 119·2°; the case might therefore be easily mistaken for one of pseudo-racemism, if no other mixtures were added; eutectic-points, however, occur at 117·8° in mixtures containing 35 and 65 per cent. of the isomerides.

(5) The active carvoximes melt at 72·0°, and unlike all the preceding compounds give a continuous melting-point curve, rising to a maximum at 91·4° in an inactive mixture of equal quantities of the two isomerides; the presence of a maximum melting-point suggests that the racemic compound which is stable at ordinary temperatures is also formed at the melting-point, but it is pointed out that such a maximum might also occur in a case of pseudo-racemism.

(6) The most interesting case is that of the camphoroximes, which always melt at 118·8°, whatever may be the proportion in which they are mixed The pure substances pass at 112·6° from a regular α-modification to a doubly-refracting β-modification; in mixtures of the two isomerides the transition-point is lower, and falls to a minimum at 109·4° in the case of a mixture in equal proportions. It is shown that in these cases no racemic compound is present, although one is formed at ordinary temperatures on crystallising from solution; the transition from the racemic compound to an externally compensated mixture takes place at 103°, and falls rapidly in presence of an excess of either active isomeride, but the complete curve has not yet been traced.

T. M. L.

1701. *Chemical Kinetics and Free Energy of the Reaction* $2HI + 2Ag \rightleftarrows 2AgI + H_2$. **H. Danneel.** (Zeitschr. Phys. Chem. 33. pp. 415–444, May 18, 1900.)—The equilibrium point in the reaction was determined by shaking up silver and silver iodide in a dilute solution of hydriodic acid under a determinate atmosphere of hydrogen. The silver was used in the form of sponge, and the attainment of the equilibrium was hastened by the addition of platinum black. The equilibrium was approached from both sides, and found finally to correspond to a hydriodic acid concentration equal to 0·043 normal, for hydrogen under ordinary atmospheric pressure.

The reaction-velocity was investigated by determining in the apparatus itself the conductivity of the solution at measured intervals. The results indicated that the reaction must be written : $H. + Ag \rightleftarrows Ag. + H$, and not $2H. + 2Ag \rightleftarrows 2Ag. + H_2$. Measurements of the E.M.F. of the cell $Ag/AgI - HI - HI/H_2$ did not lead to satisfactory results. F. G. D.

1702. *Spontaneous Decomposition of Thiosulphuric Acid.* **A. F. Holleman.** (Zeitschr. Phys. Chem. 33. pp. 500–501, May 18, 1900.)—H. von Oettingen [see 1900, Abstract No. 1525] has expressed the view that, on mixing a solution of a thiosulphate with an acid, formation of sodium sulphite and sulphur takes place immediately, the sulphur remaining in solution in the liquid. This view had previously been put forward and shown to be correct by the author (Recueil des trav. chim. 14. p. 71). Further, the author criticises v. Oettingen's conclusion that the decomposition of thiosulphuric acid is due to the action of the H ions on the S_2O_3 ions, and maintains, as was stated in his paper, that the decomposition may take place among the non-ionised molecules of the acid.

T. H. P.

1703. *Boiling-Point Curves.* **C. L. Speyers.** (Amer. Journ. Sci. 9. pp. 341–344, May, 1900.)—The reduction of the vapour pressure of the constituents of various liquid mixtures has been employed to determine the molecular weights of the liquids. The author now shows that, knowing the molecular aggregations of the constituents in a homogeneous mixture of two liquids, it is possible to plot the boiling-point curve of such a mixture. The equation employed is $n/(N + n) = (p - p')/p$, where $p - p'$ is the diminution in vapour pressure produced by the addition of n molecules of one liquid to N molecules of the other. For a mixture of carbon tetrachloride and benzene, the boiling-point curve for a pressure of 760 mm. of mercury is obtained as follows : The molecular weights of these liquids being probably normal in the mixture, we have $N + n = 100$, and the above equation becomes a straight line for each constituent and the vapour pressure curve of the mixture is a straight line having the vapour pressures of the two pure constituents for its terminals, the composition of the mixture being denoted in molecular percentages by the abscissæ. The vapour pressures of the two liquids are at 81° both above, and at 76° both below, 760 mm., so that the boiling-point of the mixture lies between 76° and 81°, and the points where the horizontal pressure-line of 760 mm. cuts the vapour pressure curves for the different temperatures between 76° and 81° are points on the boiling-point curve of the mixture. The curve agrees well with that determined experimentally by Haywood. The same is the case for mixtures of chloroform and carbon tetrachloride and of benzene and chloroform. With a mixture of benzene and ethyl alcohol, in which Lehfeldt has shown that both components have complex molecular weights, the boiling-point falls rapidly until the molecular percentage of ethyl alcohol reaches about 10, after which the curve runs for some distance approximately parallel to the axis of abscissæ, and finally rises sharply to the boiling-point of the alcohol.

When the two constituents of a homogeneous liquid mixture have normal molecular weights for all concentrations, the boiling-point curve will be a straight line, when $dp_2/dt_2 = dp_1/dt_1$, p_1 and p_2 being the vapour pressures of the constituents at the temperatures t_1 and t_2. If, however, $dp_2/dt_2 > dp_1/dt_1$, then the boiling-point curve is convex or concave towards the axis of abscissæ according as p_2 is greater or less than p_1. Only when at least one of the constituents of a liquid mixture has an abnormal molecular weight can the mixture have a minimum boiling-point, and this is in general the case when neither liquid has the normal molecular weight in the mixture.

T. H. P.

1704. *Isothermals and Isochors for Dissociation Reactions.* **K. Ikeda.** (Zeitschr. Phys. Chem. 33. pp. 287–294, May 2, 1900.)—The equations $(\partial/\partial T)\log r = -s/RT^2$ and $(\partial/\partial T)\log K = q/RT^2$ are determined by consideration of isothermal cyclical processes applied to a solution contained in a cylinder which is separated from other cylinders by diaphragms that are permeable by one or the other or both of its components. Here r denotes the ratio of the osmotic pressures of a component in an ideal and in the actual solution, the ideal solution containing the other component only in negligible quantity; s the heat given out on passage of a molecule of this component from the actual to the ideal solution; K a relation between the concentrations of the components which is constant at constant temperature; q the heat of transformation. R. E. B.

1705. *Determination of the Transition-point of Monotropic-dimorphous Substances.* **R. Schenck.** (Zeitschr. Phys. Chem. 33. pp. 445–452, May 18, 1900.)—In monotropic substances the transition-point lies above the melting-point, so that one form is always labile and the other always stable; the labile form has the lower melting-point, and when fused may resolidify to crystals of the stable form. Enantiotropic substances can be converted into monotropic substances if the melting-point is lowered below the transition-point by adding a foreign substance (Schenck and Schneider, Zeitschr. Phys. Chem. 29. p. 546, 1899); the lowering of the melting-point of each form is proportional to the proportion of the substance added, and the two melting-point lines intersect in the transition-point. In monotropic substances the transition-point cannot be realised experimentally, but in some cases it is possible to plot the melting-point curves of both modifications for successive additions of a second substance, and their point of intersection can be determined by exterpolation. If U is the transition-point and S S′ are the melting-points of the two forms, then $\frac{U-S}{U-S'} = \frac{\Delta}{\Delta'}$ where Δ, Δ' are the depression constants for the two forms. In the case of *m*-nitro-*p*-acet-toluid the stable white modification melts at 93·32, and has $\Delta = 87{\cdot}03$, whilst the yellow labile modification melts at 91·58°, and has $\Delta' = 99{\cdot}03$; the transition-point is then calculated to be 105·9°; the added substance was in this case methyl oxalate. In the case of *m*-chloronitrobenzene (m.p.'s 44·2° and 23·7°), dinitrochlorobenzene, *p*-tolylphenylketone and triphenylmethane, the labile modification was too sensitive to allow of the determination of a depression-constant. In the case of monochloracetic acid (m.p.'s 56·3 and 61·5°), the two depression constants did not differ appreciably, showing that the heat of the transformation is very small, or the transition-point distant. T. M. L.

1706. *Solubility of a Mixture of Salts having a Common Ion.* **C. Touren.** (Comptes Rendus, 130. pp. 1252–1254, May 7, 1900.)—The author finds from his solubility measurements that KCl and KBr form isomorphous mixtures. F. G. D.

1707. *Cryoscopic Behaviour of Nitro-derivatives in Formic Acid Solution.* **G. Bruni** and **P. Berti.** (Accad. Lincei, Atti, 9. pp. 273–279, April 22, 1900.)—On determining the freezing-point depressions of formic acid, solutions of nitro-, dinitro-, and trinitro-benzene, trinitrotoluene, picryl chloride, picric acid, methyl picrate, *p*-nitrobenzoyl chloride, nitromethane, nitroethane, and chloropicrin, the authors find that, whilst the aromatic nitro-derivatives all show more or less dissociation, the fatty compounds exhibit quite normal cryoscopic behaviour. Picric acid is dissociated to about the same extent as its methyl salt, and as the other polynitro-derivatives; so that the degree of dissociation is not influenced by the presence of hydroxyl, but tends to increase with the number of electro-negative groups in the molecule. The presence of small quantities of water is found to be without effect on the dissociating power of formic acid. The dissociation of nitro-compounds in formic acid solution may be explained by either of the hypotheses: (1) The nitro-group may be converted into the isonitro-group >NOOH, which would be susceptible of ionisation; but in benzene derivatives this conversion would not take place readily, as the iso-group would be joined to two different carbon atoms, whilst in fatty compounds, where the formation of the isonitro-group is easy, no dissociation occurs. (2) The formic acid may unite directly with the nitro-derivative forming a compound, R.NO(OH)(COOH), capable of dissociating; addition compounds analogous to these have been obtained by the action of methyl alcohol on trinitrotoluene and by the addition of potassium cyanide to trinitrobenzene. The second of these hypotheses is the more probable. T. H. P.

1708. *Reversibility of Voltaic Cells.* **T. S. Moore.** (Phil. Mag. 49. pp. 491–496, May, 1900. Paper read before the Physical Society of London.) —The reversibility of cells of the Daniell type was tested by measuring E.M.F. and potential difference—(1) when the cells were supplying a small current, (2) when a small reverse current was caused to flow by a known E.M.F. The cells examined were copper-zinc and copper-cadmium cells, with sulphates and chlorides of the metals. The internal resistance was found to be practically the same when calculated from these two sets of readings, thus indicating reversibility. Tests of a Clark cell did not give such good results, probably owing to the fact that a relatively large current had to be used. W. R. C.

1709. *Temperature-Coefficient of the Lead Accumulator.* **F. Dolezalek.** (Zeitschr. Elektrochem. 6. pp. 517–519, April 19, 1900.)—From the Helmholtz equation, $\frac{\partial E}{\partial T} = \frac{E}{T} - \frac{U}{23073T}$, and the relation $E = 1{\cdot}92 + 0{\cdot}15 \log_{10} c$ the author deduces the equation—

$$\frac{\partial E}{\partial T} = 0{\cdot}52 \log_{10} c + \text{const. (in millivolts)},$$

which holds for 18° C., and connects the temperature-coefficient of the E.M.F. of an accumulator with the concentration (in grm.-mols. per litre) of the acid. For small concentrations (as in the present case) U is practically independent of the concentration, so that the second term on the right-hand side is a constant. The relation holds from $c = 0{\cdot}1$ to $c = 0{\cdot}0005$. According to this the value of $\frac{\partial E}{\partial T}$ must assume large negative values for small values of c.

From his experiments the author finds that the temperature-coefficient sinks rapidly for values of $c < 2$, becoming zero for $c = 0{\cdot}70$. It is, therefore, positive or negative according to the concentration of the acid.

From Streintz's measurements of the heat-evolution in a working cell the author calculates (for several concentrations of acid) the values of $\frac{\partial E}{\partial T}$, and finds a moderate agreement with his observed values. He shows that for very dilute acid the E.M.F. is a linear function of temperature, and points out the efficiency of such an accumulator as a thermo-element (for $c=0{\cdot}0005$, a voltage of 0·6 for 90° C. temperature-difference). The great dilution of the acid would, however, render such an arrangement commercially useless. F. G. D.

1710. *Liquid Ammonia.* **C. Frenzel.** (Zeitschr Elektrochem. 6. pp. 477–480, March 22; 485–489, March 29; 493–500, April 5, 1900.)—The experiments of Cady [see 1898, Abstract No. 188] on the electrolytic conductivity of liquid ammonia and of solutions of various salts in it, although carried out with a very impure commercial product containing moisture, show that liquefied ammonia possesses a very considerable dissociating power. The author, using ammonia carefully purified by distillation and recondensation, finds for the conductivity the value, in $\text{ohm}^{-1}\ \text{cm.}^{-1}$ units, $1{\cdot}33 \times 10^{-7}$ at $-79{\cdot}3°$ and $1{\cdot}47 \times 10^{-7}$ at $-73{\cdot}6°$. By adding water to liquid ammonia, a considerable increase in its conductivity is brought about, the addition of 2·8 milligrammes of water to about 4 cubic centimetres of liquefied ammonia raising the conductivity at $-60°$ from 3·549 to 19·96 ($\times 10^{-7}$); this increase is much less than would be expected on the assumption that all the added water exists in the solution as ammonium hydroxide. Taking the conductivity at $-60°$ as the unit, the mean increase of conductivity per degree between about $-7{\cdot}93°$ and $-44{\cdot}2°$ is 1·9 per cent. In the case of impure and hence better conducting specimens of ammonia, this temperature coefficient is found to decrease as the conductivity increases; in this respect the close analogy to water is borne out. On studying the relation between the polarisation E.M.F. at the anode and the P.D. for approximately normal solutions of potassium nitrate, ammonium chloride and potassium ethyl sulphate in liquid ammonia, the author finds that for each of these salts the curve connecting the values of the quantities named shows three definite points of change, corresponding with E.M.F.'s of about 0·48, 0·66, and 0·78 volts; in the case of ammonium chloride these points are much less distinctly marked than with the other two salts. These characteristic changes in the curves must be due to the electrolytic dissociation of the ammonia molecule, and confirm the supposition that ammonia acts as a weak acid containing the anions NH_2, NH, and N. At higher voltages (1·08 to 1·15) there appears another point of decomposition, due to the anion of the dissolved substance. The curves obtained for ammonia containing small proportions of water also show characteristic points, but the latter are not nearly so conspicuous as with the salt solutions. This confirms the view that the added water for the most part remains as such in the solution, only a very small quantity being converted into ammonium hydroxide. It is also probable that the hydroxide itself is a very strong base comparable with the alkalis, the weak basic character of aqueous ammonia solutions being due to a considerable proportion of the hydroxide being decomposed into NH_3 and H_2O. On studying the kathode polarisation, it is found that the curves show a sharp change of direction at a voltage of about 0·1, owing to the presence of hydrogen ions. T. H. P.

1711. *Electrical Conductivity of Liquid Ammonia Solutions.* **E. C. Franklin** and **C. A. Kraus.** (Amer. Chem. Journ. 23. pp. 277–313, April, 1900; *cf.* Cady, Journ. Phys. Chem. 1. p. 707 1897.)—The ammonia is purified by distilling from a cylinder in which it is dried by means of sodium, into a receiver of special form; an essential feature in the purification is the filtration of the gas through asbestos which has been dried by prolonged heating; if this is omitted the distilled ammonia is always coloured blue by traces of sodium carried over in the distillation. The purity of the ammonia was determined by means of conductivity measurements, and for this purpose platinum wires were sealed into the receiver; the specific conductivity of the ammonia was readily reduced below $0{\cdot}01 \times 10^{-6}$, and did not increase when kept for some hours in the receiver, showing that ammonia, unlike water, has no action on the glass, but increased to about $0{\cdot}1 \times 10^{-6}$ in the transference to the resistance cell.

Solutions of binary salts in liquid ammonia show a remarkably great molecular conductivity, the limiting values in liquid ammonia being more than twice as great as those in aqueous solution at 18°, only slightly less than those in aqueous solutions at 100°, and far greater than those in any other known solvent. Liquid ammonia has, however, a very low dielectric constant, and the dissociation constant is correspondingly low; a degree of dissociation equal to that in an aqueous solution is only reached at a dilution about a hundred times as great, and whilst the limit in aqueous solution is practically reached at a dilution of 1,000 to 5,000 litres, that in liquid ammonia is not approached until a dilution of 25,000 or 50,000 litres is reached. The high values of the molecular conductivity must therefore be due to a very great ion-mobility. Ostwald's law holds approximately for solutions in liquid ammonia. In addition to the salts examined, which included some, such as silver iodide, which are insoluble in water, a number of organic nitro-compounds and amides were found to give conducting solutions; it is of interest to note that the amides bear the same relationship to ammonia as the acids to water, whilst sodamide, the analogue in the ammonia series of caustic soda, also gives conducting solutions.

The statement of Cady is confirmed that solutions of the alkali metals in liquid ammonia conduct without any visible decomposition. T. M. L.

1712. *Electrochemical Equivalent of Carbon.* **H. C. Pease.** (Journ. Phys. Chem. 4. pp. 38–40, Jan., 1900.)—The author has attempted to determine the electrochemical equivalent of carbon by using a carbon as an anode in the electrolysis of fused caustic potash, iron being used for the kathode. The loss of weight was determined after careful washing and drying of the anode, special precautions being taken to ensure that the caustic potash had really been removed. In five experiments the equivalent weight varied from 3·14 to 3·66; the number of coulombs was approximately the same in each experiment, the time, and therefore the current, being varied. The author concludes that the true value is 3·0. W. R. C.

1713. *Faraday's Law applied to Fused Salts.* **A. Helfenstein.** (Zeitschr. Anorg. Chem. 23. pp. 255–316, March 31, 1900.)—A number of fused chlorides, bromides, and iodides were examined, and were found to give deviations from Faraday's law amounting sometimes to as much as 100 per cent. The chief source of error is due to the diffusion of the metal and halogen through the electrolyte until recombination occurs, and this can only be avoided by using a porcelain diaphragm. The error due to solubility of the metal in the electrolyte can be overcome by previously saturating it at the temperature of electrolysis. The error due to diffusion of metal vapour into the air can be avoided by enclosing the kathode. T. M. L.

1714. *Electrolysis of the Alkali Salts of Organic Acids.* **J. Petersen.** (Zeitschr. Phys. Chem. 33. pp. 99–120, April 3; 295–325, May 2; and 698–720, June 15, 1900.)—A detailed study of the products of electrolysis of a number of acids of the acetic and oxalic series, including formic, acetic, propionic, butyric, isobutyric, valeric, isovaleric, trimethyl-acetic, caproic, oxalic, malonic, succinic, isosuccinic, pyrotartaric, ethylmalonic, and sebacic acids. The acids were used in the form of their potassium salts and the electrolyses carried out, as a rule, in slightly acid solutions at 0° and between platinum electrodes. In many cases the effect of variations in the concentration and in the current was ascertained. The results obtained are chiefly of chemical interest, and do not admit of useful abstraction. N. L.

1715. *Electrolytic Synthesis of Organic Substances. Part I.* **O. Dony-Hénault.** (Zeitschr. Elektrochem. 6. pp. 533–543, May 3, 1900.)—In the electro-synthesis of organic compounds two classes of reactions are to be distinguished: those in which the compound is formed by the interaction of the ions, as in the formation of ethane by the electrolysis of acetic acid, and those in which the liberated ions act on a non-electrolyte in the vicinity of one of the electrodes, as in the reduction of nitrobenzene to aniline. This paper is the first of a series in which it is proposed to study reactions of the second class more systematically than has hitherto been done. Stress is laid on the importance of ascertaining the exact experimental conditions favourable to each synthesis, and the E.M.F. at the working electrode is considered to be of more value than the current density as a measure of the chemical action of the ions. Every organic compound capable of entering into reaction with the liberated ions acts as a depolariser, and the requisite condition for the decrease of potential is that the reaction shall take place with loss of free energy. Thus the electrolytic decomposition point for chlorine ions in normal hydrochloric acid is 1·31 volts (compared with hydrogen), whilst in the presence of phenol the required E.M.F. is reduced to 0·9 volt. Accordingly, as some preliminary experiments have already indicated, the quantitative conversion of phenol into one or more chlorine derivatives should be made possible by careful regulation of the E.M.F. Similar observations apply to the preparation of bromine derivatives of phenol. A series of experiments, described in detail in the paper, has been carried out on the electrolysis of dilute sulphuric acid in the presence of methyl and ethyl alcohols. The results show that by keeping the anode potential between 1·3 and 1·66 volts throughout the electrolysis a quantitative conversion of ethyl alcohol into aldehyde is effected; with higher potentials the yield of aldehyde diminishes, and acetic acid and ethyl hydrogen sulphate are formed. In the case of methyl alcohol the author confirms Renard's observation that formaldehyde is not produced, the primary oxidation product being probably methylal. The paper concludes with some remarks on the analogy between chemical and electrochemical modes of oxidation, and it is shown that the limited oxidation of alcohol to aldehyde can be effected chemically by means of cupric oxide or lead peroxide in alkaline solution.

N. L.

1716. *Electrolytic Etching and Engraving.* **J. Rieder.** (Elekt. Runds. 17. pp. 139–140, April 15; and 161–163, May 15, 1900.)—In this process the article to be etched or engraved is made the anode in an electrolytic bath. In order to produce designs in relief without repeated "stopping off" with an insulating coating of the parts which are not to be etched, the author produces a liquid surface of the reversed form of the raised design to be obtained. This surface is formed by a plaster of Paris mould of the object to be copied, the back of this mould dipping into a solution of ammonium chloride, in which the kathode dips. The steel plate to be etched rests on the top of the moulded surface of the plaster of Paris block above the level of the liquid and forms the anode. On passing the current, the metal is gradually eaten away until it touches the whole of the moulded surface of the plaster of Paris. In order to enable it to be determined when the etching is complete, and to permit the particles of carbon set free from the dissolved steel to be brushed away, the author has designed a machine whereby the steel plate can be raised from the plaster of Paris, brushed and replaced exactly in its original position; it is then left in contact for 15 seconds, then raised and brushed, and so on. The current, for a steel plate 200 × 300 mm., increases up to 50 amperes at 12 to 15 volts. Further details of the process and the machine are given in the original paper, which is illustrated. C. K. F.

1717. *Electrolytic Preparation of Oxygen Salts of the Halogens.* **P. Imhoff.** (Zeitschr. Elektrochem. 6. pp. 550–553, May 10, 1900.) German Patent, No. 110420, 1898.—The decomposition of the water, or of the hydrates formed from the water, causes a considerable loss of current in many electro-chemical processes, and in the German Patent No. 66089 the inventor has sought to diminish this loss in the case of the decomposition of sodium chloride by addition of aluminium oxide to the electrolyte. This oxide forms sodium aluminate with sodium hydrate, and as the decomposition value of the aluminate is higher than that of the hydrate, the sodium is withdrawn from the action of the current.

In the electrolytic preparation of chlorates, not only the first formed hydrate, but the intermediate and final products share in the decomposition caused by the passage of the current through the electrolyte. The principle of the author's method for diminishing the loss in this case is the same; but the oxide added to the electrolyte must possess both acid and basic properties. As examples of such oxides, alumina, silicon dioxide, and boron trioxide are named. Figures are given which show that the addition of the first to a chloride solution increased the current efficiency, whether hydrate, hypochlorite, or chlorate, was considered. For a solution containing 15–25 per cent. potassium chloride, and 1·5 per cent. free alkali, the author recommends the addition of 2 per cent. alumina.

A method for determining the work performed by each portion of the current in its passage through such an electrolyte is described, this being based on Oettel's method of measuring and analysing the gases evolved at the electrodes of the cell. The results of the author's investigations are given in three tables. These show that when alumina and potassium chromate are added to the electrolyte, there is a reduction in the volume of the gases arising from decomposition of the water, or of the hydrates, and an increase of current efficiency as regards the production of chlorate. J. B. C. K.

1718. *Becker's Electrolyser for Alkalies.* (Électricien, 19. pp. 316–318, May 19, 1900.)—This electrolyser is designed for the production of metals from their fused salts or oxides, and is especially applied to the production of sodium and magnesium.

The electrolyser consists of a metallic vessel, provided at its base with a tubular aperture through which the kathode enters the vessel. The joint between the kathode and this tube is made by cooling and solidifying the salt undergoing electrolysis, at this point. The kathode is constructed of metal, and should be conical in form, to facilitate the floating upward of the globules of metal which collect upon it. Another form of kathode is described. The anode should be of carbon or of metal, according to the composition of the electrolyte. It is made annular in form, and surrounds the kathode.

The connection with the current supply is made by numerous wires attached to its external surface. The apparatus is completed by a flat cone-shaped cover, which is fixed just below the surface of the molten electrolyte over the kathode, and is designed to receive and protect from atmospheric action the metal separated at the kathode. The upper part of this collector is exposed to the air, and should it still become too heated, it can be cooled by artificial means. It is connected to the negative pole of the dynamo through a resistance. It thus acts as an auxiliary kathode, and any metal collecting underneath it is kept negatively charged until passed from the cell by the side delivery tube.

For the preparation of metallic sodium a mixture of sodium hydrate and sodium carbonate is recommended as electrolyte. The form of electrolyser described above is patented in Europe and in the States. Two cells, the one designed to utilise a current of 500 amperes, and the other a current of 1,000 amperes, are installed at the *Affinerie Electro-metallurgique de Bellegarde sur Valserine.* Three diagrams illustrate the article. J. B. C. K.

1719. *Electromagnetic Ore Dressing.* **E. Langguth.** (Zeitschr. Elektrochem. 6. pp. 500–506, April 5, 1900.)—This paper deals with the principles underlying the magnetic separation and concentration of minerals. The author explains the action as the result of the respective influence of weight, motion, and less or greater magnetism of the particles of ore. He does not agree with the recently advanced classification of weak and strong magnetic separation. Two main features are to be considered for rational separation: (1) Production of strong magnets with least expenditure of energy. (2) Separation of magnetic and non-magnetic products into divergent paths with the least amount of power. Electromagnets are the only important form used at present.

The conditions best suited for utilising magnetic energy for the purpose of separation are briefly stated to be: (1) Generation of magnetic currents of the least possible potential and the greatest density; (2) The passage of the material to be operated upon at the least distance from the magnetic poles.

Although theoretically simple, these conditions are not brought into effect in the majority of electro-magnetic separators. Very narrow fields are awkward for separation, and, on the other hand, crushing to uniform grains is not easily accomplished.

Theoretically the diameter of the grain need not exceed the width of the field, but actually at least twice the distance is required. Direct contact of the particles of ore with the bare poles is hardly feasible owing to the manner in which the ore has to be conveyed. As the material is attracted with variable intensity by the two poles, actual experiments must decide the exact distance at which it must be passed.

Experiments are then given in which the ratios between motion and magnetism are altered. The apparatus used was the ore separator of the Mecherniche Bergwerks-Aktienvereins. Distance of poles 7 mm., and material passed at variable speed 1 mm. from active pole working on a belt. Power expended 1 kilowatt, thus ensuring a very concentrated field between the poles. The artificial mixture of material consisted of same sized grains of magnetite (strongly magnetic), rhodonite (medium magnetic), and zincblende (feebly magnetic). The results obtained were as follows: (1) Velocity of belt 100 m. per minute, magnetite alone affected. (2) 70 m. per minute, rhodonite partially attracted and zincblende not at all. (3) 50 m. per minute, rhodonite completely separated, but not zincblende. (4) 40 m., partial action upon zincblende. (5) 80 m., zincblende entirely attracted. On lowering speed to 5 m. per minute the zincblende could still be magnetised with an expenditure of 20 watts.

The author therefore draws attention to the importance of adjusting the rate of travel in accordance with magnetic properties. Reference is then made to the problem of material falling vertically in the neighbourhood of a magnet, and the conclusion arrived at is that this method must be wasteful from the point of view of power expenditure unless efficient means are found of suitably diminishing the speed by obstacles. The author concludes by stating that the conditions underlying the problem of electromagnetic separation are, therefore—(1) Generation of magnetic currents of least intensity and greatest density; (2) Passage of the material to be operated upon through the magnetic field uniformly at the least possible distance from the active separative pole; (3) Variable external movement of the material under treatment; (4) Separation in homogeneous magnetic fields. O. J. S.

REFERENCES.

1720. *Electrical Energy by Oxidation of Carbon.* **W. E. Case.** (Elect. World and Engineer, 34. pp. 121–123, 1899.)—The author shows that aqueous solutions of ferric chloride are reduced by carbon in the cold. He also describes experiments with cells in which ferric chloride was used as the electrolyte, and carbon as a reducer. The E.M.F. was small. W. R. C.

1721. *Liquid Hydrogen.* **J. Dewar.** (Roy. Inst., Proc. pp. 1–14, Jan. 20. 1899. Also Chem. News, 81. pp. 137–139, March 23, and 148–151, March 30, 1900.)—A lecture given at the Royal Institution, recapitulating the researches of the author and others on the liquefaction of hydrogen. [See Abstracts Nos. 1069 (1898), 668, and 1489 (1899).] N. L.

1722. *Carbonic Anhydride of the Atmosphere.* **E. A. Letts** and **R. F. Blake.** (Roy. Dublin Soc., Proc. 9. pp. 107–229, April, 1900.)—This paper, which is too long for a complete Abstract to be given, treats exhaustively, under the following headings, of the carbonic anhydride of the atmosphere: (1) Introduction and Methods of Determination: a historical account of all the various methods proposed for the estimation of the quantity of carbonic anhydride in the air. (2) The author's improvements on Pettenkofer's process. (3) Action of baryta water on glass, and the effect of soluble silicates on the phenolphthalein colour reaction. (4) Amount of the anhydride in the air; and (5) Causes of variations in this amount. There are two appendices, the first treating of ground air and its relations to atmospheric carbonic anhydride; and the second, by W. Caldwell, containing a comparison of the results of the determination of carbonic anhydride by Pettenkofer's process with those given by the author's modification of that process. T. H. P.

1723. *Electro-deposition of Chromium.* **S. Cowper-Coles.** (Chem. News, 81. pp. 16–18, Jan. 12, 1900. Read before the Institution of Mining and Metallurgy, Dec. 20, 1899.)—A paper on the same lines as those previously noticed in Abstract No. 340 (1899). N. L.

1724. *Discharge Device for Electrical Furnaces.* (Elekt. Runds. 17. pp. 114–115, March 1, 1900.)—This is a description of a tapping device for an electrical furnace, having for its object continuity, exclusion of air, and also the cooling of the finished product before leaving the furnace. O. J. S.

1725. *Formation of Carbides.* **A. A. Beadle.** (Elect. Rev. 46. pp. 611–613, April 13, 1900.)—General consideration of formation of carbides in the electric furnace. A summary of the properties of a large number of carbides is given. W. R. C.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1726. *Combined Refuse Destructors and Power Plants.* **C. N. Russell.** (Inst. Civ. Engin., Proc. 139. pp. 181–201; Discussion, pp. 202–254, March, 1900.)—A distinction is drawn between refuse destructors designed to destroy garbage cheaply and effectively, and the economical raising of steam on a large scale by the heat generated in destructors.

The methods of dealing with refuse are classed under three heads: (i) Cheap disposal; (ii) Disposal from a sanitary point of view; (iii) Disposal with a view to steam raising.

The results obtained from Oldham, Warrington, Cambridge, and other places, are stated to have demonstrated (i) that a considerable amount of energy can be obtained from refuse furnaces, and (ii) that refuse in each locality has a fairly definite calorific value. The amount of steam raised per pound of refuse burnt shows great variations in various localities. Abroad, notably at Hamburg and Brussels, the amount of steam raised is practically negligible, and the residue nearly 100 per cent. greater than that usually found in England, where it is about 28 per cent. of the refuse.

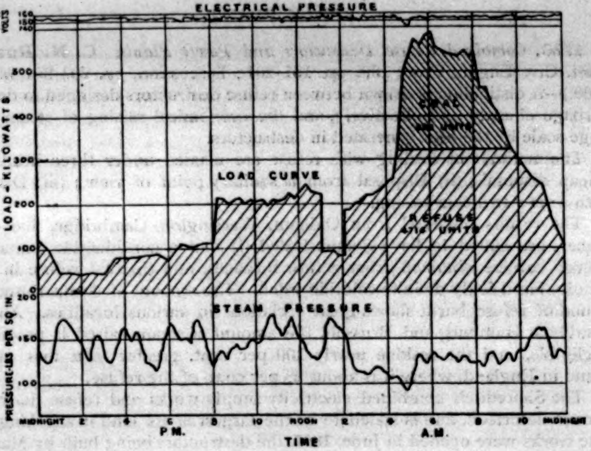
The Shoreditch combined electricity supply works and refuse destructor is next described, and is stated to be the largest of its kind in the kingdom. The works were opened in June, 1897, the destructors being built by Manlove Alliott & Co. The destructor and boiler house is separated from the electric generating station by fireproof doors. The former contains six Babcock & Willcox boilers, each having two refuse furnaces, one placed on either side of the boiler; an ordinary coal firegrate immediately under the boiler tubes is provided as an auxiliary if required. Coal is burnt as well as refuse at these works, the calorific value of the refuse not always being equal to the demand on the amount of steam.

The average amount of refuse is 84 tons per day; as much as 140 tons has been received in one day. Refuse is delivered between the hours of 9 a.m. and 5 p.m. Spare storage is provided to cope with extra heavy deliveries. The lift and tip-trucks for dealing with the refuse are worked entirely by electricity, 0·52 kw. hours being expended per ton of refuse moved, this figure being arrived at from over a year's working and a total of 25,000 tons moved. The average time required to deal with a load of refuse shot into the lifts, raised to the top platform, tipped, and empty truck returned to starting-point, is nine minutes.

Each furnace is provided with both steam and forced air draught. In the author's experience the latter is found to be preferable. The air-pressure is 3 inches at the face and 1 inch in the ashpits. The temperature obtained in the furnaces often exceeds 2,000° F. The author thinks the electrical energy necessary to drive the fans is very high, and considers that there is much room for improvement in electrically-driven fans.

The feed-water is heated by a Green's Economiser to 220° F.–250° F., and is then forced into a feed thermal storage vessel (Druitt Halpin's system). This is found useful for depositing the lime in the feed-water, of which 1,828 lbs. dry weight were found after seven months. The economiser was opened at the same time, and found to be very free from scale, deposit in the tubes being less than $\frac{1}{16}$ inch in thickness.

The author is of opinion that the feed storage system has contributed largely to the success of the plant generally, it being possible to store hot feed-water for eighteen hours out of the twenty-four.



Evaporative tests are made from time to time, of which the two following, carried out on January 10, 1899, are of interest :—

	1	2
Duration.............................	8 a.m. to 1 p.m.	8 p.m. to 8 p.m.
Water evaporated from and at 212° F...............................	72,220 lbs.	108,319 lbs.
Refuse burned	75,092 lbs.	60,700 lbs.
Coal (Powell Duffryn)............	nil	6,272 lbs.
Number of cells in use	10	10
Number of boilers in use	5	5
Water evaporated per lb. of refuse burned.....................	0·96 lb.	—

The load curve for these tests is given in the accompanying figure. The abrupt drop at 1 p.m. is due to motors in factories being switched off.

Experience at Shoreditch shows that the full evaporative efficiency of coal is not obtained when burnt in conjunction with refuse.

The following is the analysis of the refuse dealt with at Shoreditch for the year ending June, 1898 :—

	Tons.
Domestic refuse	23,137
Trade refuse (straw, paper, tan, market refuse, &c.	2,257
Wood chips, about	10
	25,404

The residue after passing through the furnace may be divided as follows :—

	Per cent.
Common clinker	29·0
Fine ash	2·7
Fine dust	0·5
Old tins	0·6
	32·8

The average moisture in the refuse is 20 per cent.

Artificial paving-stones are manufactured from the clinker, consisting of 2½ parts of ground clinker to 1 of Portland cement, ground very fine and pressed at 1¼ tons per square inch. A sample slab, when supported at its ends, sustained a weight of 2,221 lbs. before breaking.

The cost per ton ot destroying refuse works out to 2s. 4·39d. for the year ending June 30, 1898, and 2s. 6·9d. for the year ending June 30, 1899. This includes the wages of four furnace men, three top men, and one foreman, supervision and clerical staff, cleaners and yardmen, repairs, stores, &c.

The amount of electrical energy absorbed in burning and handling the refuse over one year's working is—

Electric fans	4·0 units per ton.
Electric lifts and tipping trucks	0·5 „
Electric lighting	0·48 „

Gross results taken over a year's working are :—

Total energy metered to consumers, including 131,140 units supplied to destructor	1,031,348 units
Coal consumed, value £1,308 14s. 8d.	1,344 tons
Refuse burnt	26,201 tons

The results of experience gained at Shoreditch are summed up as follows : (1) That domestic refuse in London has an average calorific value equal to evaporating 0·99 lb. water per lb. of refuse burnt. (2) That in London it can be destroyed for 2s. 5d., which is stated to be less than it would cost to barge away. (3) That the total amount of power to be obtained per annum from the whole of the refuse in London, if burned in suitable furnaces, would amount to about 133,000,000 B.H.P. hours. (4) That a combination of one boiler and two furnaces may be relied upon to evaporate 2,888 lbs. water per hour from and at 212° F. at a pressure of 200 lbs. per square inch with refuse as a fuel.

An interesting appendix is given, in which the details and results of other destructor plants in various parts are summarised.

In the discussion **S. H. Terry** remarked that in the case of forced draught some means of allowing the dust to subside should be employed. He submitted drawings of an arrangement he had devised for effecting this some years since, which is based on the principle of reducing the velocity of the gases by enlarging the flue. **F. W. Webb** said that between 4,000,000 and 5,000,000 bricks were made yearly at Crewe of refuse clay from the works. **C. Jones** considered that a high temperature in the furnace did away with necessity for a cremator. **A. H. Preece** analysed the author's figures, and pointed out that the refuse was equivalent to coal at 25s. per ton. He advocated the use of destructors as much as any one, but there was no question of getting electricity for nothing. **F. Watson** said that high temperatures always produced the hardest clinker. **E. C. de Segundo** took exception to the author's view that 1 lb. of ordinary London refuse could be relied on to evaporate 0·99 lbs. of water from and at 212° F., and analysed the heat distribution in the combustion of a pound of refuse, showing that some refuse, if very moist, would hardly burn itself. He considered systematic observations over lengthy periods necessary to obtain reliable results of the performance of destructors. **W. P. Abell** gave some interesting figures relating to steam raising by the waste product of sugar-making. Repeated and reliable experiments showed that 5 lbs. of light refuse resembling sawdust and shavings, and containing 50 per cent. moisture, are equivalent to 1 lb. of coal in useful heat effect. **E. J. Lovegrove** contributed some valuable details as to the manufacture of mortar, paving, and concrete from the clinker obtained from the burning of refuse. E. C. S.

1727. *Operating Economies in Central Station Practice.* **W. L. Abbott.** (Elect. Rev. N.Y. 36. pp. 565–568, May 30, 1900. Paper read before the National Electric Light Association, May 22, 1900.)—The author gives a method of washing used waste and extracting oil therefrom. From every 100 lbs. oily waste, 40 lbs. clean waste and 40 lbs. oil are recovered. Cylinder lubrication is discussed, and firemen's time schedule to suit the load is described. Losses from careless firing, and most economical qualities of coal are touched upon, and a device for indicating the percentage of carbon dioxide in the flue gas for the purpose of detecting bad firing is described. Diagrams are given of an oil separator, the most economical distribution of firemen's time to suit a given load curve, and the percentage of carbon dioxide in flue gases. J. T. R.

1728. *Measure of Good Quality in Governors.* **R. H. Smith.** (Engineer, 89. pp. 529–530, May 25, 1900.)—The author discusses four elements of good quality tending towards the production of quickness of action; no one of these in itself, nor any combination of them, gives a measure of this quickness. It is the object of this article to show exactly on what this quick action depends, and to formulate its correct measurement. It may be called "kinematic sensitiveness," and is a true measure of the actual speed with which the governor operates the valve or other gear, to control which is the governor's whole duty. The author defines the "geometric sensitiveness" as the "displacement at the control point (or sleeve) due to a 1 per cent. change of speed, the governor exerting no controlling force." The "force-power" is defined as "the controlling force exerted by the governor corresponding to a 1 per cent. change of speed without displacement." The "energy-power" is the "work done at the control point by the governor in a complete cycle of speed variation, through 2 per cent. up and 2 per cent. down from normal, 1 per cent. in each direction producing controlling force, and 1 per cent. producing displacement. The "stability" is the righting force-power exerted at unit displacement from normal position, when the speed is restored to its normal value.

The author discusses the resistances due to friction and inertia, and then finds the average velocity of displacement, which he calls the "kinematic sensitiveness." If it were possible to do away with all internal and external frictional resistances the frictionless kinematic sensitiveness would be—

$$\frac{2}{\pi}\sqrt{\frac{\gamma f}{M}}$$

where γ is the geometric sensitiveness, f is the force-power, and M the equivalent of the external inertia or masses. A. S.

GAS AND OIL ENGINES.

1729. *Monarch Gas Engine.* (Automotor Journal, 4. pp. 391–393, May, 1900.)—A two-stroke engine in which the explosive mixture is drawn by the piston into the crank-chamber during the compression stroke of the working cylinder, is compressed in the crank-chamber during the firing stroke, and is allowed to pass into the working cylinder during a part of the exhaust period. The piston uncovers an exhaust port before the end of its working stroke, and immediately afterwards uncovers an inlet port leading from the crank-chamber. The piston is provided with a baffle plate, which reduces the tendency of the incoming charge to pass out of the exhaust port. Ignition is effected by means of an electric spark inside the combustion chamber. A low-tension electric system is employed, the spark being produced between a fixed insulated contact piece in the cylinder head and a rocking arm, which passes through the wall of the cylinder, and which is operated by a slow make and quick break mechanism. The ignition device is worked by an eccentric upon the crank-shaft of the engine, and is so arranged that three different periods of ignition, during the compression stroke of the engine, are provided for; either of these timing positions can be used, according to the engine speed required. A battery, or a magneto-machine, is connected in series with an iron-cored solenoid and with the steel contact pieces in the combustion chamber. The motors, of which detail drawings are given, are fitted with fly-wheel governors which regulate the amount of the explosive charge drawn into the crank-chamber, and are also fitted, for launch work, with an exhaust-pipe cooling device; the latter consists of a pipe, leading from the cylinder water-jacket, which delivers a constant flow of water into the exhaust pipe. Various sizes of these motors are made, from 1 H.P. to 12 H.P. (three-cylinder). A single cylinder motor, having 3½-inch bore and 3½-inch stroke, develops 1·2 B.H.P. when running at 600 r.p.m. A. G. N.

1730. *Blowing Engine Worked by Blast Furnace Gas.* **A. Greiner.** (Mech. Eng. 5. pp. 728–729, May 26, 1900. Abstract of a paper read before the Iron and Steel Institute, May, 1900.)—This paper gives a short abstract of results obtained at the Cockerill Works with the first blowing engine worked by blast furnace gas. A brake test of the engine was made, and the mean power during the day was 575 H.P., the speed being 80 r.p.m. and I.H.P. about 700. Next day the brake was taken off, and the engine run as a blowing engine, the mean power developed being 725 H.P. The calorific value of the gases was on the average 984 calories per cubic metre as determined by Witz's calorimetric bomb, 860 as measured by Junker's calorimeter. The heat was expended as follows: 30 per cent. converted into work in the cylinder, 50 per cent. carried off by the water-jacket, and 20 per cent. carried off by the escaping gas. Drawings are already in hand for three 1,200 H.P. blowing engines; while of 48 gas engines of this type at present ordered three are for works which could not have been established if the new invention had not been brought into effect, *i.e.*, in situations where water is entirely absent.
A. S.

1731. *Dawson Oil Engine.* (Automotor Journal, 4. pp. 321–324, April, 1900.)—A four-stroke motor in which a compressed-air system is incorporated into the engine itself in order (1) to start it automatically in either direction, by utilising air which has previously been compressed, (2) to recharge a compressed-air reservoir, (3) to scavenge the working cylinder during the exhaust stroke, and (4) to increase and vary the amount of explosive charge which is taken into the engine cylinder. The cylinder is nearly twice the ordinary length and contains a double piston ; the back end is of one diameter and the front portion is of a larger diameter. Each part of the piston fits into, and works in its respective portion of the cylinder. The smaller cylinder and piston constitute the oil engine proper, while the annular space between the smaller piston and the larger cylinder enables that portion of the motor to be utilised either as an air pump or as a pneumatic engine. A passage leading from the rear end of the larger cylinder is provided with a slide-valve, which is controlled by an eccentric as in a steam engine ; the eccentric is mounted upon a shaft in such a manner that it can be made to assume a concentric position or to secure a reversing action upon the slide-valve, by being returned to an eccentric position, but at an angle of 180° from its original position. The slide-valve controls communication between the cylindrical annular space and a valve chest, which is connected to an air reservoir and to a port leading into the working cylinder. The valve-chest contains two slide-valves, which are connected together and which are operated by hand ; the one valve controls the passage from the air cylinder into the valve-chest, and the other controls a port leading into the working-cylinder. The two valves alternatively open or close one or other, or close both, of the passages which they control, but the former also acts as a non-return valve from the valve-chest to the air cylinder, when it is normally closed. An air reservoir is provided, and this communicates with the valve-chest by means of a pipe containing a non-return valve. The non-return valve can be opened by a hand lever when it is desired to start the engine with compressed air, and the reservoir is fitted with a safety valve. The oil-motor cylinder is fitted in much the usual way, with inlet and exhaust valves and with a variably-timed high-tension electric ignition device ; the petrol is fed to the mixing chamber by a pump, and the cams are fitted in duplicates so that one set allows the engine to work in each direction. The motor is fitted with three complete cylinders, in order to avoid dead points ; it is started by admitting compressed air to the air cylinders ; its working cylinders are scavenged by allowing the air, which is compressed by the larger cylinders, to pass into the working cylinder at the end of each firing stroke ; the explosive charge is augmented at the end of each suction stroke in a similar manner. The working cylinders are 3¼ inches in diameter, the air cylinders are 4½ inches, and the stroke is 5 inches ; the air reservoir normal pressure is 60 lbs. per square inch, and it has a capacity of 7 cubic feet ; the speed of the motor is from 400 to 800 r.p.m., and the B.H.P. is about 8·8 with a normal charge, and about 12·5 when fully augmented with compressed air. A. G. N.

AUTOMOBILISM.

1732. *Gardner Serpollet Steam Motor Car.* (Automotor Journal, 4. p. 341, April, 1900.)—This article describes the general arrangement of the machinery of a Serpollet car propelled by the steam motor described in Abstract No. 903 (1900). It also gives a sketch of the Serpollet oil and water-feed apparatus, the action of which is described by reference to a diagram of water and oil connections. W. W. B.

1733. *Dupressoir Motor Car.* **P. Sarrey.** (Locomotion Automobile, 7. pp. 311–313, May 17, 1900.)—This article describes a voiturette, which includes a special form of change gear constructed by Dupressoir, the different speeds being operated selectively by means of cone clutches.

The illustrations show in elevation and plan the main elements of the voiturette, and a two-speed change gear in sectional elevation. W. W. B.

1734. *Winton Petroleum Spirit Motor Car.* (Indus. and Iron, 28. p. 151, March 9, 1900.)—This article describes a petroleum spirit motor vehicle in which the departures from the most usual practice are the arrangements of petrol feed and air carburation.

The valve for admission of air to the cylinder traverses the carburetted air admission from the mixing chamber, and passes into a small dashpot cylinder, the piston of which is fixed to the end of the valve stem. The nut which fixes this piston also fixes a bent spring which carries a pointed valve; this has a seating in a petrol nozzle, which enters one side of the air admission pipe to the mixing chamber. Thus at every charge admission stroke of the motor piston, a carburetted air charge is taken from the mixing chamber, and a new charge of air and petrol admitted into the chamber. The movement of the pointed petrol valve is limited by an adjusting screw, and the dashpot forms a governor because of the automatic variation of the movement of the charge admission valve with variation of the motor piston speed. The maximum speed of the engine as controlled by this governor is adjustable by an air cock on a pipe, opening the inside of the dashpot to the atmosphere.

The electrical ignition apparatus is of the low-tension magneto type, with tappet make and break inside the charge admission port.

The engine is placed in the direction of length of the car, and drives by spur gear a countershaft having two clutch-controlled speeds, and a final drive by chain to a short pinion spindle, gearing with a spur wheel on the differential gear-box. Speeds between those of the gear at normal speed of the engine are obtained by varying the speed of the latter, all ordinary running being done by the direct driving upon the differential gear. A general arrangement of the car machinery and sections of the motor from patent drawings are given. W. W. B.

1735. *Mors Motor Car.* (Automotor Journal, 4. pp. 342–343, April, 1900. From La France Automobile.)—This is briefly descriptive of the four cylinder 10 H.P. (nominal) Mors carriage, with which recent high-speed records have been made. Diagram views of the motor and of the electrical ignition connections are given. W. W. B.

1736. *Estcourt Water Cooler.* (Automotor Journal, 4. pp. 333–335, April, 1900.)—This article describes a tubular water cooler for water-cooled motors, so arranged that the heated water rises to the upper part of the system of piping, and being cooled by radiation falls therefrom to the lower part of the system, and thus keeps up a natural circulation of the contained water. To obtain the necessary radiating surface the cooler is made larger in height than usual, and so placed in the front of the car and on the dashboard that it receives the full effect of the air current. As a supplementary means of circulation a self-acting bucket valve is placed in one of the columns carrying the cooling tubes. This valve rests upon a coiled spring of light resistance, but of sufficient strength to carry the bucket normally at a given position. In running over the roughness of an ordinary road the movements of the car are sufficient to bring into play alternately the inertia of the valve and the recoil of the spring, thus setting up movement of the water in one direction. The object of the apparatus is to dispense with either pump or fan. W. W. B.

GENERAL ELECTRICAL ENGINEERING.

1737. *Electricity Meters.* **A.** and **V. Guillet.** (Comptes Rendus, 130. pp. 1549–1551, June 5, 1900.)—The number of oscillations of a magnetised needle within a coil traversed by a current, or of a second coil in series with the first, is proportional to the quantity of electricity passing through the coil in the same time; this is the fundamental principle of the Boys and Blondlot quantity meters. In order to apply the method to the measurement of energy, the continuous force acting on the moving system must be replaced by an impulsive force. For this purpose the authors employ an oscillating coil suspended in a magnetic field, which may be constant (in which case the meter measures quantity), or may be proportional to the supply pressure (in which case the meter measures energy), the circuit through the moving coil being closed momentarily only.

The constant field may be produced by a magnet, while the variable field is produced by a coil connected in shunt to the supply terminals. To maintain the vibration, in the author's model the shunt coil is suspended, and makes a contact at each end of its swing; the counting train is driven by the motion of the coil. Mathematical proofs of the theory are given. A. H. A.

1738. *Automatic Electric Signals at the Paris Exhibition.* (Engineering, 69. pp. 647–649, May 18, 1900.)—A description of I. A. Timmis's system installed by A. Lavezarri on the electric railway. This is a single line, about two miles long, and has four signalling points. The signal is of the disc type, fitted in an iron framework, closed in front with clear glass and behind with opal glass. The latter is illuminated powerfully at night. The arm consists of fine red calico on a light frame, and is operated by a small long-pull electromagnet worked with twelve Leclanché cells or five accumulators. Each signal has two electrical contacts fitted near the rails on the outer side, the first a breaking-contact, and the second, a little ahead, a making-contact. These are actuated by a striking bar, which is fixed to the train, knocking against arms or hangers belonging to these contacts. On leaving a station the train knocks open the breaking-contact, the local circuit is broken, and the signal, no longer held down by its electromagnet, goes to "danger" by gravity. This movement of the arm switches in the line circuit to the rear signal, so that as the train proceeds and knocks the making-contact a current is sent to that signal and the arm is pulled down to "line clear." Another train can thus enter the rear section. Upon leaving the second station a similar series of operations is performed by means of the striking-bar. The breaking-contact is opened, the arm rises and switches in the line circuit to the signal outside the first station, and the making-contact occurring immediately afterwards sends a current through that switch, pulling down the arm of the signal outside the first station, thus clearing the line.

A resistance comes into circuit locally at the time when the arm has been lowered in order to reduce the consumption of current for holding the arm. This economy of current is a most essential feature of the system.

The above description applies to absolute automatic working. For permissive working the connections can be altered to allow of particular places, not sections, being protected. For instance, at a curve, the breaking-contact can be knocked over and the arm lifted as the train enters it, and the making-contact can be placed so as to operate and to permit the same signal to drop when the train leaves the curve. E. O. W.

1739. *Properties of Carbon in Electrical Work.* **Elihu Thomson.** (Elect. World and Engineer, 35. pp. 703–705, May 12, and 787–788, May 26, 1900. Abstract of a paper read before the North Eastern Section of the American Chemical Society in Boston).—The author deals seriatim with the uses of carbon for various electrical purposes. In the first place the employment of arc-lamp carbons is entered upon, and it is shown that no mixture of carbon with other substances has been successful in replacing the pure carbon. The value of carbon for electrodes for arc lamps is ascribed to its absolute infusibility and high temperature of sublimation. The latter is said to be, according to Violle, about 3,500° C. Before the volatilisation the carbon is converted into pure plumbago, and it is this that gives rise to mushroom growths on the negative carbon when the carbons are too close together.

Reference is made to the Acheson method of making graphite by passing very heavy currents of electricity through artificial carbons embedded in loose carbon. With regard to incandescent lamps, the universal use of carbon filaments is referred to, and the method of preparation and flashing the filaments is explained.

Further the employment of carbon in telephone transmitters is explained and its advantages discussed. Finally, the introduction of carbon brushes to replace metal ones on continuous-current motors is shown to have been a great boon in motors for traction purposes.

An account of a modified carbon brush, which the author has had in successful use for over 7,000 hours, is given, and the method of construction is explained. J. L. F. V.

1740. *Depreciation of Machinery.* **R. H. Smith.** (Feilden, 8. pp. 270–281, March, 1900.)—The depreciation of a machine in the course of one year is the change in the capitalised present value of its net earning power, taking into account the probable duration of its remaining life. The capitalised value of the earning value of a new machine is, if it be well chosen and skilfully placed, more than its money cost by the value of the intelligence employed in selection and placing. A mathematical expression is obtained for the depreciation of the present intrinsic and extrinsic value, and curves are plotted from which it is clear that the prevalent notion of decreasing the rate of depreciation towards the end of a machine's life is erroneous : such yearly depreciation should increase. The author contends that in a *bonâ fide* concern the selling value of the plant is altogether a wrong value to attach to machines, instead of their working value. Examples and tabular explanations are given. M. O'G.

REFERENCES.

1741. *Coal-Handling Plant at the Wandsworth Electric Lighting Station.* (Engineering, 69. p. 524, April 20, 1900.)

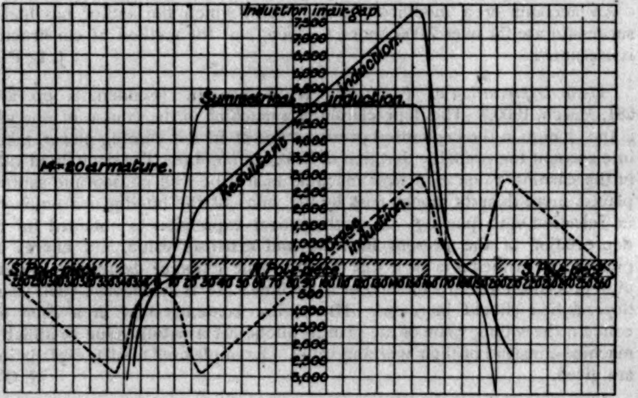
1742. *Mechanical Applications of Electricity.* **G. Richard.** (Écl. Électr. 20. pp. 241–253, and 21. pp. 361–368, 1899 ; 22. pp. 328–336, March 3, 1900.) *Descriptions of Sprague and Heerman and Whichello Elevator, and Slow-travelling Crane* (pp. 241–253.) The Motor Controllers of Englewood, Davis, Russell, and the Rapps Indicator (pp. 361–368). For preceding parts see 1898, Abstract No. 555, and 1899, Abstracts Nos. 744, 1250, and 1769.

GENERATORS, MOTORS, AND TRANSFORMERS.

1743. *Subdividing Dynamo P.D. by means of Choking Coils.* **A. Sengel.** (Elektrotechn. Zeitschr. 21. pp. 387–391, May 17, and 410–413, May 24, 1900.)—The author works out the theory of the various arrangements shown in the diagram of Abstract 1263 (1899). He next describes a series of experiments made with the view of testing the theoretical deductions. The results obtained show approximate agreement between the two. A. H.

1744. *Air-gap Induction in Continuous-Current Dynamos.* **C. C. Hawkins** and **R. Wightman.** (Inst. Elect. Engin., Journ. 29. pp. 436–457, April, 1900.)—Within the bore of the pole-pieces the lines may be taken as radial and uniform in density over 85 per cent. of the polar arc; for 7½ per cent. at each end the lines begin to curve outwards and the density diminishes. Beyond the pole-tip the length of a line at any point A is $\xi(c-x)+l_g$, where c = distance on the periphery from the line of symmetry to the radius drawn to the pole tip, x = distance from the line of symmetry to the point A, l_g = air-gap, and ξ is a constant estimated from the drawing. In a two-pole armature with poles covering 120°, ξ = about 2·2.

If X_p = total ampere turns, X_g the A.T. for the double air-gap, X_a = A.T. required to overcome the armature reluctance, X_b = back A.T., θ = half the interpolar angle, λ = angle of lead, then the difference of magnetic potential between the pole-tip and a point distant by angle a from line of symmetry is—



$$1{\cdot}257\left(\frac{X_g}{2}+\frac{X_a(\theta-a)}{2\theta}\right)$$

up to the angle of lead; and between this and the line of symmetry it is—

$$1{\cdot}257\left(\frac{X_g}{2}+\frac{X_a(\theta-a)}{2\theta}+\frac{X_b(\lambda-a)}{2\lambda}\right).$$

The following table and curves give the figures, worked out for an armature, 35·6 cm. diameter, 1·42 cm. air-gap, pole face 140°, λ=10°, 232 conductors, and total armature current 160 amperes.

Angle from Line of Symmetry. $=a$.	Length of Path in cm.	Diff. of Potential.	$\frac{\text{Col. 3.}}{\text{Col. 2.}}$	Deduct	Symm. Induction.	Cross M.M.F.	Cross Induction.	Leading Induction.	Trailing Induction.
0°	14·42	8,100	560	560	0	5,180	359	— 359	359
2°	13	7,950	611	504	107	5,180	398	— 291	505
4°	11·5	7,800	678	448	230	5,180	450	— 220	680
6°	10	7,650	765	392	373	5,180	518	— 145	891
8°	8·6	7,500	872	336	536	5,180	602	— 66	1,138
10°	7·17	7,350	1,025	280	745	5,180	722	+ 23	1,467
12°	5·8	7,310	1,260	224	1,036	5,050	870	+ 166	1,906
14°	4·2	7,270	1,730	168	1,562	4,920	1,170	+ 392	2,732
16°	3	7,230	2,410	112	2,298	4,790	1,596	+ 702	3,894
18°	2·4	7,190	2,990	56	2,934	4,660	1,940	+ 994	4,874
20°	1·95	7,150	3,660	0	3,660	4,530	2,320	+ 1,340	5,980
22°	1·7	7,150	4,200		4,200	4,400	2,590	+ 1,610	6,790
24°	1·5	7,150	4,760		4,760	4,270	2,850	+ 1,910	7,610
26°	1·44	7,150	4,955		4,955	4,140	2,870	+ 2,085	7,825
28°	1·43	7,150	5,000		5,000	4,010	2,810	+ 2,190	7,810
30°	1·42	7,150	5,040		5,040	3,880	2,730	+ 2,310	7,770

The paper also gives a mathematical determination of the total number of lines forming the fringe which surrounds the polar faces. R. B. R.

1745. *Direct-Current Motors.* **P. Houel.** (Électricien, 19. pp. 227–231, April 14, and 266–268, April 28, 1900.)—The motion of the armature of a direct-current motor is given by—

$$\frac{d\omega}{dt}=\frac{\Sigma \mathrm{MF}}{\Sigma mr^2},$$

where $\frac{d\omega}{dt}$ is the angular acceleration, $\Sigma\mathrm{MF}$ is the sum of the moments of the couples acting on the armature, and Σmr^2 is the moment of inertia of the armature, say $\mathbf{M}$.

Also—

$$\Sigma\mathrm{MF}=\frac{2\mathrm{I}\Phi}{\pi},$$

where I is the armature current, and Φ is the number of conductors multiplied by the total flux through the armature. The counter E.M.F $=4\Phi\mathrm{N}$ where N is the number of revolutions per second. This may be written—

$$e=4\Phi\mathrm{N}=\frac{2\Phi\omega}{\pi}.$$

If E is the applied potential difference we get—

$$\frac{d\omega}{dt}=\frac{2\mathrm{E}\Phi-\pi\rho\Sigma\mathrm{MF}}{\pi\rho\mathbf{M}}-\frac{4\Phi^2\omega}{\pi\rho^2\mathbf{M}},$$

whence—

$$\omega=\frac{\pi}{2}\cdot\frac{\mathrm{E}}{\Phi}\left(1-\frac{1}{\mathrm{E}}\cdot\frac{\pi\rho\Sigma\mathrm{MF}}{2\Phi}\right)\left(1-1\Big/e^{\frac{4\Phi^2}{\pi^2\rho\mathbf{M}t}}\right).$$

As t increases this becomes—

$$\omega=\frac{\pi}{2}\cdot\frac{\mathrm{E}}{\Phi}\left(1-\frac{1}{\mathrm{E}}\cdot\frac{\pi\rho\Sigma\mathrm{MF}}{2\Phi}\right),$$

Or—

$$N=\frac{E}{4\Phi}\left(1-\frac{1}{E}\cdot\frac{\pi\rho\Sigma MF}{2\Phi}\right).$$

When the angular velocity is steady this becomes—

$$N=\frac{E}{4\Phi}$$

The time taken to attain a steady velocity is given by—

$$t=5{\cdot}685\frac{\rho M}{\Phi^2}\log n$$

Where—

$$1-1\Big/e^{\frac{4\Phi^2}{\pi^2\rho Mt}}=\frac{n-1}{n}$$

W. G. R.

1746. *Slip-ring and Commutator Losses.* **G. Dettmar.** (Elektrotechn. Zeitschr. 21. pp. 429–436, May 31, 1900.)—The main object of this paper is to establish rules for the best sizes of brushes. The losses occurring with carbon brushes, which are gradually superseding copper ones, are considerably higher than when these latter are used. The subject of slip-rings is considered first. Curves are given showing the variation of the contact resistivity (*i.e.*, the resistance per square cm. of contact area) with peripheral speed for various currents, its variation with current for various speeds, and its variation with pressure for a given current, for both copper and carbon brushes. These curves clearly bring out the following points: (1) The change of contact resistivity with speed is dependent to an extraordinary degree on the material of which the brushes are made; in all cases there is a rapid initial increase of resistivity as the machine starts from rest; with copper gauze brushes the resistivity becomes practically constant beyond a speed of 1 metre per second. With brushes of sheet copper the resistivity reaches a maximum, and then decreases with further increase of speed; with brushes of sheet brass there is a steady increase of resistivity within all ordinary limits of speed; lastly, carbon brushes give results similar to those obtained with copper gauze brushes. (2) The contact resistivity always decreases with increasing current density, although the exact law connecting these two quantities depends on the material of the brushes. (3) The contact resistivity steadily decreases with increase of pressure. Since the electrical loss at the surface of contact decreases, while the friction loss increases, with increase of mechanical pressure, it follows that for a given current density there will be a certain value of the pressure which gives the least total loss. The author finds that under average conditions a pressure of 125 grammes per square cm. for copper gauze, and 140 grammes for carbon brushes, gives the best results. It is next shown that, assuming the above values of the pressure, it is best with copper gauze brushes to use as high a current density as possible, while in the case of carbon brushes the best area of contact is given by the formula—

$$S=\frac{I}{3{\cdot}79\sqrt{v}}$$

where S is the total surface of contact of the brush, in square cms.; I the current, and v the peripheral velocity, in metres per second.

The author next deals with commutators, where the presence of insulation between the segments introduces a complication. Curves are given similar to those described above for slip-rings. The curves show that, for both copper and carbon brushes the contact resistivity steadily decreases with increase of current density, and that for a given pressure and given current density it becomes, after a rapid initial rise, practically independent of the speed beyond a value of 2 metres per second. This latter result is in direct opposition to those obtained by Arnold [see 1899, Abstract No. 1266], but the author has proved experimentally that if the commutator is even slightly out of truth, the resistivity passes through a maximum as the speed is increased. With copper brushes it is best to work with the highest permissible current density and the least permissible pressure; while in the case of carbon brushes, assuming a pressure of 149 grammes per square cm., the best contact area is given by—

$$S = \frac{I}{0{\cdot}9 + 0{\cdot}71v}$$

The last section of the paper deals with the rise of temperature. A. H.

1747. *Motor Control for Printing-Presses.* (Amer. Electn. 12. pp. 196–198, April, 1900.)—The Cutler-Hammer Manufacturing Company of Milwaukee have worked out a multiple-solenoid system for automatically controlling the speed of large rotary presses. The low speeds of the motor required when "making ready" are obtained by shunting the motor armatures by a resistance and putting both in series with another resistance. The shunting resistance is automatically controlled by solenoids operated by relays. A complete diagram of the somewhat complicated connections and a detailed account of the operation of the system is given. E. H. C.-H.

1748. *Rotary Converter.* **E. Wilson.** (Inst. Elect. Engin., Journ. 29. pp. 409–435, April, 1900.)—The paper contains an account of experiments carried out with two similar continuous-current machines fitted with slip-rings, one of the machines acting as a two-phase generator and supplying power to the other, which ran as a rotary converter, being loaded on the continuous-current side. By means of instantaneous contact-makers, curves of P.D., current, and E.M.F. were obtained. These are given in the paper. The mechanical phase displacement of the converter armature was studied by means of the device explained in Abstract No. 752 (1900). Armature reaction has the effect of producing periodic fluctuations in the P.D. on the continuous-current side. Speed fluctuations of the generator due to a joint in the belt were found to cause oscillations of the converter armature. The concluding section of the paper deals with the regulation of rotary converters. The method of regulation by means of a variable reactance interposed between the generator and converter is discussed, and is compared with the method of compounding the converter. A. H.

1749. *Inductive E.M.F. in Transformers.* **J. B. Whitehead, Jr.** (Elect. World and Engineer, 35. pp. 660–662, May 5, 1900.)—The author explains, by means of a vector diagram originally given by Steinmetz, the effect of magnetic leakage in causing a drop of P.D. under various conditions of load. He next proceeds to calculate approximately, from the dimensions and relative positions of the coils, the values of the leakage inductances, on the assumption that the thickness of the insulation may be neglected. This investigation leads to the result that if the primary and secondary are divided into the same number of parts, which are then placed alternately, the leakage E.M.F. decreases with increasing subdivisions, approximately as the square of the number of subdivisions of either coil. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1750. *Long-distance Power Transmission*. **G. Forbes.** (Inst. Elect. Engin., Journ. 29. pp. 629–657; Discussion, pp. 658–677, May, 1900; and in the Electrician, June 1, 8, 15, and 22, 1900.)—The paper consists of two parts. Part I. contains brief descriptions of the power plants at Los Angelos, Snoqualmie Falls, Paderna, Rheinfelden, Genoa, and Niagara. Part II. deals with Lord Kelvin's law of economy, the use of boosters and synchronous motors for supplying the idle component of the current, the relative merits of different kinds of polyphase systems, overhead and underground conductors, and the use of aluminium. The author draws special attention to the Thury system of power transmission [Abstracts Nos. 874 (1898) and 1369 (1900)], and states that in many cases this would give better results than a polyphase system. In connection with Kelvin's law of economy the following points are of importance: (1) When using water-power which is unlimited compared with the demand, the price of a H.P. hour is to be taken as the price of *generating* it; if, on the other hand, the supply of power is limited and the demand unlimited, the price is to be taken as that of *selling* a H.P. hour. (2) If the copper is mortgaged, the interest to be allowed on its price is the interest paid on the mortgage, say 4 per cent.; but if the copper is paid for out of capital, the interest is that to be paid in dividends on the capital, say 15 per cent. Tables are given showing the weight of copper per H.P. and kw. delivered at the receiving end of a transmission line 100 miles long with 10,000 volts at generating end—(1) without boosters; (2) with boosters, when the line is divided into two, three, and four sections respectively. The effect of inductance in increasing the drop along the line is next considered, and a table is given, by means of which the magnitude of this effect may be determined for various distances apart of the conductors in the case of a single-phase transmission. In comparing polyphase systems the author gives preference to the two-phase system, mainly on account of the fact that the two circuits may be electrically disconnected, either always, or else during tests; this facilitates the localisation of faults and gives greater security of working. In connection with the use of aluminium conductors, the author mentions that the chief drawback to its use, especially overhead, is its liability to become rotten; this defect does not exist if the metal be pure and especially free from sodium. He suggests painting or varnishing aluminium conductors.

In the discussion **Ferranti** expressed the opinion that rotary converters would give place to motor-generators, and that polyphase systems would be superseded by the single-phase one. **G. L. Addenbrooke** pointed out that very good lighting work could be done with a three-phase power plant. **A. H. French** contributed a full description of the Thury plant at Genoa.

In a further discussion of the paper by correspondence in the columns of *The Electrician*, **Perry** drew attention to the fact that in the tables given in the paper, efficiencies below 50 per cent. are given, whereas any case in which the efficiency happens to fall below this limit may, without changing the conductor, be converted into another having an efficiency of over 50 per cent. by simply increasing the P.D. across the motor terminals. He also pointed out that the booster system, which had been patented by Elihu Thomson many years ago, was of no practical value, and that it was better in every case to transmit without the intervention of boosters. In reply, **Forbes** stated that the booster system was of importance only in special cases of unlimited cheap power, long distance, and no excessive voltage. **A. M. Taylor** showed, by working out a number of results covering the range of practice and plotted in the form of curves, that even with water-power costing only £1 per H.P. year it would not be economical to work with an efficiency below 50 %. A. H.

1751. *Power Transmission at Duluth, Minnesota.* **F. W. Springer.** (Elect. World and Engineer, 35. pp. 545–547, April 14, 1900.)—*The St. Louis River* drains an area of 38,000 square miles composed of pine land, swamps, lakes, and some arable land. The rainfall is about 30 inches per annum, and there are two periods of low water, one from summer drought, and the other from the freezing-up of the small streams and swamps, many of which freeze solid. The minimum flow occurs in winter, when the power may be estimated at 15,000 H.P. at a head of 600 feet. Recently a St. Louis power development company has been formed, and it is proposed to cut a canal four miles in length and to lay 800 feet of pipe line to a power station in the bed of the stream. This will give 350 feet head, or about 10,000 H.P. at minimum flow.

The Black River scheme is similar to the above. A masonry dam 20 feet high is to be built, which will give a head of 55 feet and a flow of water of 6,000,000 cubic feet. The pipe line is to be 54 inches diameter, and will be buried to prevent freezing. Two direct connected polyphase 800 kw. generators are to be installed, together with five (one reserve) oil transformers for raising the pressure from 440 to 18,000 volts. The pole line will consist of 35-feet cedar poles, 8 inches diameter at the top and set 52 to the mile, with three pin cross arms and 24-inch spacing. The conductors will be No. 1 bare copper mounted on three part Locke insulators.

The interesting point about these schemes is that, although many propositions have been made and much money spent, the development of the power running to waste did not become practicable until the application of long-distance transmission by electricity. With the prospect of the immediate development of such powers it looks as though what had long been hoped for would come to pass—that is, the beginning of the manufacture of iron and steel at Duluth and Superior. It is estimated that it will not cost more than $55 per H.P. to distribute the power. E. K. S.

1752. *Balancers for Three-wire Systems.* **F. S. Hickok.** (West. Electn. 26. pp. 280–282, May 5, 1900. Paper read before the Chicago Electrical Association, April 20, 1900.)—After a brief introduction, the author shows the necessity of devices for equalising the pressures on both sides of a three-wire system, and describes several methods by which this may be accomplished. In addition to the usual methods, it is possible to use either a single battery on only one side of the system, or a small generator mechanically coupled to a large one, and taking the place of the battery mentioned above, or various arrangements of motor-generators. The author recommends the latter system, using compound-wound machines; when the load is out of balance, one machine runs as a differentially wound motor, the other as a compound wound generator, and by proper adjustment of the compounding it is possible to obtain automatic regulation within 1 per cent. under all conditions. The precautions required to ensure success are briefly discussed, and instances given of the application of the system in practice.

A. H. A.

1753. *Electrical Equipment of Ships of War.* **C. E. Grove.** (Inst. Elect. Engin., Journ. 29. pp. 580–602; Discussion, pp. 602–626, May, 1900.)—The paper applies chiefly, but not solely, to British practice. Part I. deals with general equipment. The standard lighting pressure is 80 volts, and the dynamo speed about 300 r.p.m., but 500 r.p.m. has been introduced with forced lubrication. The output varies by steps of 100 amperes up to 600. The ironclad type of dynamos has been practically superseded by multipolar machines, which have but little stray field. The British standard switchboard, which is described, does not allow of working the dynamos in parallel; other boards are described which provide for this, and the system of distribution is explained, with a schedule of lamps. Lead-covered rubber-insulated conductors are used, all stranded cables being multiples of No. 20 S.W.G., with a current density of 1,000 amperes per square inch; the cables are cleated to teak battens or direct to bulkheads, &c. The author describes a simple device, consisting of a slab of rubber and iron plates, for watertight glands, as well as other methods. Distribution boards are used for the lighting circuits, on which all fuses are collected; double wire circuits are standard. Lamps are hooked on the ends of the actual leads, in special watertight fittings. The navigation and signal lanterns are described at some length, with the alarm devices to indicate failure, and methods of signalling for various purposes with Ardois and Scott lanterns. For searchlights, the Parsons parabolic mirror is used, with inclined and horizontal hand-fed lamps. A Siemens automatic projector is also described, and the method of signalling by flashes explained. Communication between different points is of a complex character, and not altogether satisfactory as yet. Electric bells are used in conjunction with speaking-tubes; and the Graham loud-speaking telephone is also employed, but for use in warfare some form of printing telegraph is suggested. Torpedo and gun-firing circuits are always single-wired; for the former, two batteries are used, and the connections are so arranged that they can be readily tested, and the operations of opening the sluice-valve and completing the preparations respectively signalled to the conning tower, at which point the firing-key is placed. For gun-firing the circuits are confined to the firing station. Electrical range-finders and telegraphs are briefly described, as well as engine-room telegraphs, tiller transmitters, and revolution indicators.

Part II. of the paper is concerned with machinery and power distribution. Diagrams are given showing the location of the auxiliary machines, comprising upwards of 100 sets in a typical battleship. Ordinary enclosed traction motors are the most suitable type to meet the excessively severe conditions obtaining on board ship. The losses incurred in the use of steam are considered in detail, with examples, and the conclusions arrived at by J. K. Robison [see 1900, Abstract No. 929] as to the comparative weight and economy of electrical and steam auxiliaries are disputed, the author stating that on a ship with a bunker capacity of 2,000 tons, 262 tons would be saved in 25 days by the substitution of electricity for steam. Electromotors are particularly suited for driving fans, which on a battleship require about 100 E.H.P. for the boiler and engine-rooms alone; for forced-draught air-pumps, about 200 E.H.P. would be necessary. The application of electric driving to steering gear is discussed; this would require a motor of 150 H.P. on a large ship. For the capstans, motors of about 50 to 100 H.P. would be used; in some British ships the forward capstan is driven by steam and the after capstan by electricity. These machines have to work under very arduous conditions. Motors of 50 E.H.P. are used for boat and coal hoists, and about 5 H.P. for ash hoists. Six or eight fans, taking 5 E.H.P. each, were formerly used for general ventilation, but recently about twice as many smaller fans have been substituted. Electricity has been little used in the British Navy for working guns, but in the United States and other navies its use for this purpose has been highly successful. It is important that turrets should be well balanced about the axis of rotation. Ammunition hoists are commonly worked by electricity. Particulars and numerous illustrations of all the apparatus mentioned are given. Summing up, it is estimated that a total motor capacity of 1,885 E.H.P. would be required, with a maximum possible demand of 1,385 E.H.P.; the probable maximum demand would be 1,015 E.H.P. Lighting would call for 100 kw., including projectors. About 800 kw. installed would be sufficient for the generating plant; for this the author suggests three sets of 200 kw. each and four of 50 kw. each. The question of using polyphase currents is discussed, but direct current is preferred. The author considers also the advisability of raising the standard pressure, and prefers a two-wire 200-volt supply to the three-wire system at 160 volts between the outers (a footnote states that the British Admiralty has now authorised the use of 100-volt dynamos). Ring mains are advocated, to diminish risk of injury in battle. The author concludes by a further comparison of steam and electrical plant, estimating the net increase in weight with the latter to be 55 tons, with a saving of 262 tons of coal in 25 days' steaming.

The discussion consisted largely of criticism of the policy of the British Admiralty. Apart from this, **S. Evershed** gave additional information respecting his engine-room telegraphs; **R. E. Crompton** urged the advantages of horizontal carbons with automatic feed and short focus mirrors for search-lights, and the superiority of electrical motors over steam and hydraulic machinery; **A. E. Richards** gave a large amount of general information, dealing principally with experience gained in the British Navy, and including the results of actual trials of electric fans, hoists, and capstans; **H. Wilde** supplied interesting historical details; **F. L. Noakes** stated that open motors, not in exposed places, were more durable than the enclosed type. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1754. *Dortmund Electricity Works.* **J. R. Dick.** (Electrician, 45. pp. 42–45, May 4, and 81–85, May 11, 1900.)—*System:* Continuous current in urban, and three-phase in suburban areas, both for lighting and power. The *boiler-room* contains water-tube boilers, 170 lbs. working pressure, with superheaters. Efficiency 70 per cent. when working at 140 lbs. and 27° F. superheating, burning good steam coal. The *engine-room* contains four 600 I.H.P. horizontal compound condensing engines running at 90 r.p.m. The steam consumption is 14·3 lbs. per H.P. hour when working at 500 I.H.P. Two of the engines drive directly 30-pole continuous-current twin dynamos with distinct armatures and common magnets. Each armature gives 200 kw. at 220 to 370 volts. Two armatures can be coupled in parallel for charging batteries or three-wire system, or in series for traction. The remaining two engines drive directly 400-kw. 2,600-volt three-phase generators, having a periodicity 50, excited from the continuous-current 'bus bars. The feeders are of steel armoured lead-covered single cables not exceeding 0·3 square inch area, at a potential difference of 200 volts with no middle wires. There are 18 feeders radiating from the first substation, 16 from the second, and 9 from the third. The average section is 0·15 square inch. The distributors are of steel armoured lead-covered cables, with earthed middle wire of bare tinned copper, all having an equal section. The three-phase distributors are three-core lead-covered steel-armoured, laid directly in the ground. The voltage is 2,600 volts reduced to 120 volts by single transformers on consumer's premises. The three substations are each equipped with a Gottfried Hagen battery of 132 accumulators, having a capacity of 3,536, 1,768, and 1,768 ampere hours respectively; efficiency 80 per cent. in kw. hours. The price charged is 6d. per unit for lighting and 2½d. per unit for power, with discounts based partly on units sold and partly on load factor of kw. installed. *Drawings:* Scale plan of engine-room, diagrams of switchboard connections, load curves, and maps of mains. J. T. R.

1755. *Coventry Electricity Supply.* (Elect. Rev. 46. pp. 833–837, May 18, 1900.)—*System:* High tension alternating with grouped transformers. The *boiler-room* contains four Lancashire boilers each capable of evaporating 5,000 lbs. of water per hour. Two of these are 30 ft. × 7½ ft. and two 30 ft. × 8 ft. diameter. Induced draught is produced by a fan drawing the waste gases from the economiser and delivering into the chimney above the damper. The chimney is 100 ft. high by 5¼ ft. sq. The feed-water is heated by a Green's Economiser. The coal is fired by Proctor mechanical stokers fitted to each boiler, driven by a small Tangye engine. The *engine-room* contains three horizontal low speed rope-driven generating sets of 50, 100, and 200 kw. respectively, and a direct coupled Belliss-Fynn set of 300 kw. The horizontal engines are compound by J. Fowler & Co. The Belliss engine is a three-crank compound running at 368 r.p.m. Each horizontal engine drives by means of ropes an alternator of the Hall type working at 2,000 volts, 87 periods, with revolving fields and stationary external armatures. The vertical engine is direct-coupled to a Fynn alternator of the inductor type, made by Easton, Anderson & Goolden under Mordey's patents. Its output is 150 amperes at 2,000 volts. The exciters, in the case of the rope-driven machines, are rope-driven from the alternator shafts, but that for the Belliss set is carried on the bedplate and driven by an extension of the shaft. The distribution of current is briefly as follows: the high tension mains are concentric paper-insulated lead-covered cables laid on the solid system; there are 9 substations, and 3 districts fed by transformers placed in boxes beneath the pavement. The current is transformed down and supplied to the low-tension network at 200 volts. The low-tension distributing mains, however, are not interconnected between substations, and can all be disconnected by switches in their respective substations. The equivalent of 17,806 8-c.p. lamps is connected. The price charged is 6d. for one hour and 3d. afterwards per unit for lighting, and 2d. per unit for power. The method of charging is the "Wright" system. E. H. C.-H.

1756. *Three-phase Transmission Plant at the Humboldt II. Coal-Mines, Brüx.* **A. Kolben.** (Zeitschr. Elektrotechn. Wien, 18. pp. 266–271, May 27, 1900.)—A description of a three-phase mining plant laid down by the Elektricitäts Actien Gesellschaft, formerly Kolben & Co., of Prague. The generators are belt-driven by two 170-H.P. horizontal engines running at 170 r.p.m.; they have 14 poles and give 2,150 volts at 50 cycles per sec. Particulars are given of the substation in which the voltage is reduced to 360, and of the various circuits and motors for ventilating, &c. E. K. S.

1757. *Polyphase Transmission at Montpelier (U.S.A.).* **J. L. Thomas.** (Elect. World and Engineer, 35. pp. 544–545, April 14, 1900.)—The plant now opened by the Consolidated Lighting Company, of Montpelier, is composed of a water-power generating station at Bolton Falls on the Winooski River, Waterbury; a steam plant and two step-down transformer houses in the city; and a step-down transformer house that is being erected at Barre, six miles from Montpelier, and twenty-three miles from Bolton Falls. The water-power plant consists of two 450 kw. General Electric three-phase, 60-cycle, generators, delivering current direct to the line at 11,000 volts. They are direct connected to horizontal turbines operating under a head of 50 feet. The seventeen miles of line between Bolton and Montpelier consists of three No. 4 bare copper wires supported on porcelain insulators on a 6 pin cross arm. Three more wires are to be added later for power work. The step-down transformers are 100 kw. of the air-blast type, 11,000 to 2,000 volts, and are provided with expulsion cutouts and oil switches. E. K. S.

1758. *Electrical Equipment of a Packing House.* **J. E. Smith.** (Amer. Electn. 12. pp. 201-208, May, 1900.)—At the great Armour meat-packing establishment in Chicago sixteen scattered steam engines were previously used, but these have now been replaced by a compact electrical generating plant supplying power to motors throughout the works. The boilers are of the Wickes vertical water-tube type, and each is rated at 375 H.P. They supply steam to three Corliss compound condensing engines, each of which is coupled direct to a 550-volt dynamo, supplying current for motors, and is also coupled by ropes to an 1100-volt alternator for incandescent lighting. The motors range from 1½ to 200 H.P., and number altogether 111, aggregating 3,600 H.P. In most cases one motor is used for each floor, single reduction toothed gearing being generally employed between motor and shafting. Compressed air motors are installed in the cold-storage rooms. W. H. E.

1759. *Electrical Equipment of the Chicago Great Western Railway Shops.* (Amer. Electn. 12. pp. 177–178, April, 1900.)—The generating plant consists of three 100-kw. Crocker-Wheeler machines, driven by two tandem compound Ideal engines. Engines and generators are coupled by magnetic clutches and run at 250 r.p.m. One engine has sufficient capacity to drive two of the generators, the other is half the size; but the smaller engine is provided with an auxiliary steam connection by which high-pressure steam may be admitted to the low-pressure cylinder, thus furnishing means by which the engine may be run on 100 per cent. overload: the mechanical parts of this engine are designed with this in view. Three Stirling boilers are installed under a guarantee to evaporate into steam containing not more than 3 per cent. moisture, from and at 212°, eight pounds of water per lb. of coal burned with a draught of 0·6 inch at the base of the stack; the calorific value of the coal being taken as 11,500 B.T.U. per pound. The exhaust steam is passed through oil extractors and used to heat the building.

Current for both motors and lamps is supplied at 220 volts; there are six hundred 16-c.p. incandescent lamps and fifty-one 1,200-c.p. arc lamps used. All tools and machinery are driven by electric motors, except some pneumatic tools in the boiler and erecting shops, and the air lifts. The contract requires that all motors shall deliver their rated output for 18 hours per day, with an average efficiency for all sizes of not less than 88 per cent. at full load, 86 per cent. at three-quarters load, and 88 per cent. at half load; to be capable of carrying 25 per cent. overload for two hours with safety, and in starting to be able to develop 50 per cent. more than their rated output. Thirty motors, varying in size from 2 H.P. to 60 H.P., are used in the shops. All are Crocker-Wheeler machines except a G.E.-52 motor for the transfer table and the motors on the machine shop crane. The transfer table takes current from two overhead wires, and is capable of carrying the largest coach and the heaviest locomotive used in railway practice. The tools of the machine shop are driven by belts from two lines of shafting each 75 feet long and each driven by a 20-H.P. motor. The two shafts can be coupled together by an Arnold magnetic clutch, so that one motor may be used to drive the two. The boiler-shop tools are driven by one 20-H.P. motor in a similar manner. The bulk of the power is used in the wood mill, where there are five shafts each driven by a motor. The blacksmiths' shop is equipped with down-draught forges, with Sturtevant fans driven by a 25-H.P. motor, also a small steam hammer, a punch and shear, and a forging machine, driven by a 10-H.P. motor. In the yard the turntable, the coal-shoot, and other labour-saving apparatus are also to be equipped for electric power.

The article is illustrated by two views of the generating plant and a vertical cross-section showing the arrangement of the power house. E. D. P.

1760. *The Waterloo and City Railway.* **H. H. Dalrymple-Hay.** (Inst. Civ. Engin., Proc. 139. pp. 25–55, March, 1900.)—Previous schemes were abandoned owing to cost of property required for the construction of an ordinary line with a City terminus. A junction with the South-Western line was impossible owing to the great difference in levels, the rails being 41 ft. below those of the South-Western Railway. At the City terminus the rails are 59 ft. below the surface of Queen Victoria Street. In the construction of the works a stage with shafts in the river formed the base of operations. The direction of the work below ground was tested through check borings in three places by means of fine piano wire and plumb-bobs. The errors in direction were very small. Measurements were made underground by ½ in. or ¾ in. steel tapes and corrected to the horizontal by levelling and calculation. Two temporary shafts, 16 ft. internal diameter and 45 ft. long, of cast iron, were sunk from the timber stage just above Blackfriars Bridge over the line of each tunnel, through which the excavated material was raised in skips by cranes and barged away. The two tunnels, one for up and the other for down trains, were driven by means of four Greathead shields and lined with cylindrical cast-iron lining 12 ft. 1¾ in. diameter inside the flanges on the straight or curves of not less than 9 chains radius, and 12 ft. 9 in. on those of 5 chains radius. Red rubber or yarn was used for making the joints in water-bearing strata, and rust joints elsewhere. The Greathead shield was used exclusively for tunnelling in clay. It consisted of an iron cylinder 13 ft. 2 in. diameter, 7 ft. long, armed with a cutting edge of slightly less diameter, at its forward end, which was provided with a diaphragm of iron plate having an opening 6 ft. 6 in. by 5 ft. 6 in. through which the excavated material from the front of the shield was removed. The shield was pushed forward by 7 hydraulic rams attached to the shield, the heads taking a bearing on the flanges of the cast-iron tunnel lining which was built within the tail of the shield so as to follow it up. The space between the excavation and the cast iron lining was filled with a lime grout. In order to assist excavation short piles were pushed forward by the shield and detached lumps of clay which were removed by miners from the front of the shield and afterwards by skips through the temporary shafts to barges. The rate of tunnelling was about six complete 20 in. rings of cast-iron liners, or 10 ft. per day of twenty-four hours. In water-bearing strata tunnelling was more difficult. Compressed air at about 12 lbs. pressure per square inch was employed to prevent the water from leaving the ballast and so causing a settlement overhead. The excavation in the front of the shield had to be timbered to prevent the roof and "face" from falling in before the shield could be pushed forward. In some cases the roof timbering was built in, but where decay was probable it was removed. A modified or "hooded" shield, 9 ft. 6 in. long, having more powerful rams and a long cutting edge, which could be pushed forward into the ballast before excavating, was subsequently employed. The shield for the 23-ft. tunnels is described, as are also the works at Waterloo and the City, the lifts, and the system of drainage.

The paper is illustrated by three plates giving a map, gradients and levels of the route, and illustrations of the shields and some of the works. A discussion followed the next paper on "The Electrical Equipment of the Waterloo and City Railway" [see following Abstract]. J. T. R.

1761. *Electrical Equipment of the Waterloo and City Railway.* **B. M. Jenkin.** (Inst. Civ. Engin., Proc. 139. pp. 56–96; Discussion, pp. 97–176, March, 1900.)—The trains are worked by electrical energy from the power station at the Waterloo end of the line. The power house, consisting of boiler house, engine-room, workshops, and offices, contains five Davey Paxman boilers, 14 ft. long, 8 ft. diameter, each with two flues 2 ft. 8 in. diameter, and 92 tubes of 3 in. internal diameter. Heating surface 1,180 sq. ft., grate surface 18·5 sq. ft., working pressure 160 lbs. per sq. in. The boilers are fitted with Vicar's mechanical stokers. The 140-ft. chimney has an area of 43 sq. ft., and gives a draught of between ½ in. and ¾ in. of water, with four boilers working. The feed-water is heated by a Green Economiser in two parts, having together 480 tubes, 4 in. diameter. The engine-room contains six three-crank, vertical, double-acting Bellis engines, each indicating 360 H.P. at 385 r.p.m. Each drives directly a Siemens two-pole drum dynamo, compounded to give 500 volts at no load, and 530 volts at full load. The flywheels weigh 6 tons. Condensation is by an evaporative condenser above the feed tank outside the boiler house. Coal is brought by the London and South-Western Railway, and lowered in trucks by the main carriage lift, thence by electric locomotive to a 20-ton hydraulic lift, by which it is lifted 17 ft. to a siding outside the boiler house. Below is a coal store into which the trucks are emptied. The Westinghouse brake reservoirs on the trains are charged by air pumps through a storage reservoir at 100 lbs. pressure. The tunnels and stations are lit by the equivalent of 1,848 8-c.p. lamps, generally 5 in series on the 500-volt circuit. Two main feeders, each ¾ sq. in. section, consisting of two cables in parallel are carried to link boxes in Waterloo station, and branches are carried through links to the different sections of conductor rail in the main line and sidings. From Waterloo a single lead-sheathed jute insulated cable, 0·5 sq. in. sectional area, is run down each tunnel and forms the feeder for that tunnel. The conductor rail, consisting of a steel channel 4 in. by 2 in., with 4·5 sq. in. section, is carried on porcelain oil-insulators attached to the permanent way transomes, and is divided into nine sections which can be disconnected from the feeder. The resistance of the conductor rail with bonds and connections was found to be 0·051 ohm per 1,000 yards. The permanent way is of standard South-Western pattern, having bull-headed rails weighing 87 lbs. per yard. The rails and conductor rail are bonded by copper bars, 2 in. by ½ in. in section, hydraulically riveted to the rails at each end by three ¾ rivets. The running rails are cross bonded every 100 ft. by

0·125 sq. in. cable, and the rails in the separate tunnels are connected at each of the ten connecting passages. A return copper conductor 1 sq. in. section is connected every 100 ft. between each pair of rails for a distance of 3,800 ft. from Waterloo. A train consisting of four carriages, each carried by two four-wheeled bogies, will carry 204 passengers. One bogie of each of the two end carriages carries two 60-B.H.P. motors driving the axles directly without gearing. There is a clearance of 5 in. between the tops of the carriages and the tunnel. On each motor carriage two collecting-shoes make contact by rubbing on the conductor rail. The controllers have eight working positions, and place all four motors in series or parallel.

The following are the results of a whole day's test during running hours :—

1.	Date of test	December 29, 1898
2.	Duration of test, 7 a.m. to 10.35 p.m.	15 hrs. 35 mins.
3.	Total coal burnt	18,600 lbs.
4.	„ water evaporated	169,000 lbs.
5.	„ units generated	2,160 kilowatt-hours
6.	„ „ taken by lighting and pumps ...	730 „ „
7.	„ „ „ for working trains	1,430 „ „
8.	Number of journeys run (Up and Down counted as one journey)	112
9.	Number of passengers carried (estimated)	12,000
10.	Total train-miles run	325
11.	Average weight per train, including passengers (estimated)	93 tons
12.	Total ton-miles run	30,225
13.	Water evaporated per lb. of coal, actual ...	9·09 lbs.
14.	„ „ „ „ from and at 212° F.	9·72 lbs.
15.	Coal per unit generated	8·6 lbs.
16.	Calorific value of coal	12,140 B.T.U.
17.	Coal per train-mile (excluding pumping and lighting)	37·8 lbs.
18.	Coal per ton-mile (excluding pumping and lighting)	0·407 lbs.
19.	Water per unit generated	78·2 lbs.
20.	Units per train-mile	4·4 kilowatt-hours
21.	„ „ ton-mile	0.047 „ „
22.	Average units per Up journey	5·26 „ „
23.	„ „ „ Down journey	6·36 „ „
24.	„ „ „ journey for shunting at Waterloo	1·15 „ „
25.	Load factor	33·5 per cent.
26.	Maximum observed momentary load at power house	330 kilowatts
27.	Maximum load averaged over 6 minutes ...	201 „
28.	Mean volts at generating station	505 volts
29.	Maximum observed drop in pressure on return circuit from City to Waterloo ...	4·4 volts
30.	Mean observed drop in pressure on return circuit from City to Waterloo	1·62 „

In the Discussion **G. Forbes** pointed out that probably the reason for having motors at each end of the train was the difficulty of transferring a single motor car from one end of the train to the other at the termini. Half the power was pulling and half pushing, which, though not seriously dangerous, was probably the reason why the Board of Trade objected to the intended speed (24 miles per hour) round sharp curves. The diminished speed (15 miles per hour) at which the trains were allowed to run had made a difference to the general speed. **Carus-Wilson** drew attention to the gain by using roller bearings, the average resistance being 6 lbs. or 7 lbs. per ton instead of 18 lbs. per ton given by McMahon for the City and South London Railway. **W. R. Galbraith** referred to the restrictive clauses in Electrical Railway Acts which had been unfairly introduced. He thought it would have been better had the Central London Railway tunnels been 12 ft. diameter, and the station tunnels 23 ft. diameter as for the Waterloo and City line, than 11 ft. 6 in. and 21 ft. respectively. He strongly recommended the hooded shield propounded by Hay where there was danger of settlement. **G. F. Deacon** thought that tunnels should be well below the suface of the London clay to prevent disturbance of the surface; that access should be by numerous hydraulic lifts; and that grouting pressure should be continuously maintained quite up to the shield, while the cutting edge should always penetrate the face of clay. **E. W. Moir** advocated the Sprague multiple-unit system, and pointed out the advantage of rapid acceleration thereby obtained in keeping up the average speed. **A. B. W. Kennedy** mentioned the inequality of the load due to a six-minutes train service. He did not think other engines were better than high-speed engines for electric traction. **E. Thomas** called attention to the advantages of cut-off governing, by which the average load could be made the most economical. **H. H. Dalrymple-Hay,** in reply, said that the rate of tunnelling depended on the time required for the grout to set. **B. M. Jenkin,** in reply, said that the compounding of the dynamos was a disadvantage to the lighting: the variations in load were so rapid that the machines could not follow them. The volts lagged behind, the current making the pressure more unsteady than when working with shunt machines. He agreed that expansion-governing compared to throttle-governing made it possible to overload an engine to a much greater extent.

There are six plates illustrating the shields, tunnels, generating station, rolling stock, motors, &c. J. T. R.

REFERENCES.

1762. *Arc Lamps.* **G. Richard.** (Écl. Électr. 23. pp. 161–168, May 5, 1900.)—An article dealing with recent patent specifications, and containing the various patent drawings. The lamps described are the Wood, Prentis, Warner, Chagnaud, Woltmann, Mozer, Davy and Upton lamps. [See also Abstracts Nos. 958 (1899), and 777 (1900).]

1763. *Berlin Metropolitan Railway.* (Tram. Rly. World, 9. pp. 217–226, June, 1900. Translated from the Elektrotechn. Zeitschrift.)—Article giving particulars of the scheme proposed by the Union Elektricitäts-Gesellschaft for the employment of electric traction.

TELEGRAPHY AND TELEPHONY.

1764. *Wireless Telegraphy with Free Balloons.* **J. Vallot,** and **J.** and **L. Lecarme.** (Comptes Rendus, 130. pp. 1305–1307, May 14, 1900.)—It was proved (1) that an earthed wire is not indispensable for a long-distance transmission, and (2) that signals were clear even though the two vertical antennæ were vertically above one another. M. O'G.

1765. *London Telephone System.* (Elect. Rev. 46 pp. 774–775, May 11, and 815–816, May 18, 1900.)—This is a description of the proposed Post Office system. The area extends from Reigate northwards to Waltham Abbey, and from Romford westward to Harrow, and embraces about 600 square miles. Work will be commenced in the Embankment, Westminster, and Kensington sub-areas, to be followed immediately by the City work and the suburbs later. The Central Exchange will be in the Savings Bank building, Queen Victoria Street. Exchanges at Westminster, Kensington, Wimbledon, Putney, Richmond, Chiswick, Kingston, and Twickenham will be opened almost simultaneously. The cables to be employed are paper-insulated and lead-sheathed. For subscribers' lines the conductors will weigh 20 lbs. per mile, the mean diameter being 35·5 mils. and the maximum resistance 43·89 ohms per mile. The junction lines will weigh 40 lbs. per mile, have a mean diameter of 50 mils., and a maximum resistance of 21·94 ohms per mile. The largest cables will be for subscribers' lines, 217 pairs; for junction lines, 108 pairs. Tables give sizes of cables and particulars of number of pairs, mean thickness of lead, maximum external diameter, average weight per mile, also number of pairs in each layer of stranded cable. The mean wire-to-earth capacity of each wire is 0·08 mf. per mile. The mean wire-to-wire capacity of each pair must not exceed 70 per cent. of the mean wire-to-earth capacity. The insulation resistance is 10,000 megohms.

The ducts to be used for the conduits will be of glazed earthenware. In some cases fifty of these ducts will be used in one trench. The section of conduit is illustrated. The ducts will be built in cement according to a method which is described and illustrated. Jointing chambers—or manholes—will be of two classes, one for roadway, another for footway, and they will vary according to the number of cables to be brought in. Dimensions of three standard sizes are given, and the construction is described.

The switchboards for the Central Exchange will be fitted to accommodate 10,000 subscribers, Westminster and Kensington Exchanges for 2,000 subscribers, "outer" sub-exchanges for 600 subscribers, with provision for subsequent additions.

The system of working will be the "central battery system" in the City and the inner sub-exchanges. The action of lifting the receiver causes a lamp to light and the attention of the operator is gained automatically. Other features of the working of the central battery system are briefly referred to.

The rates to be charged for service are not yet published, but they will probably be on the "toll" rate system. J. E. K.